VOLUME 60 NUMBER 3

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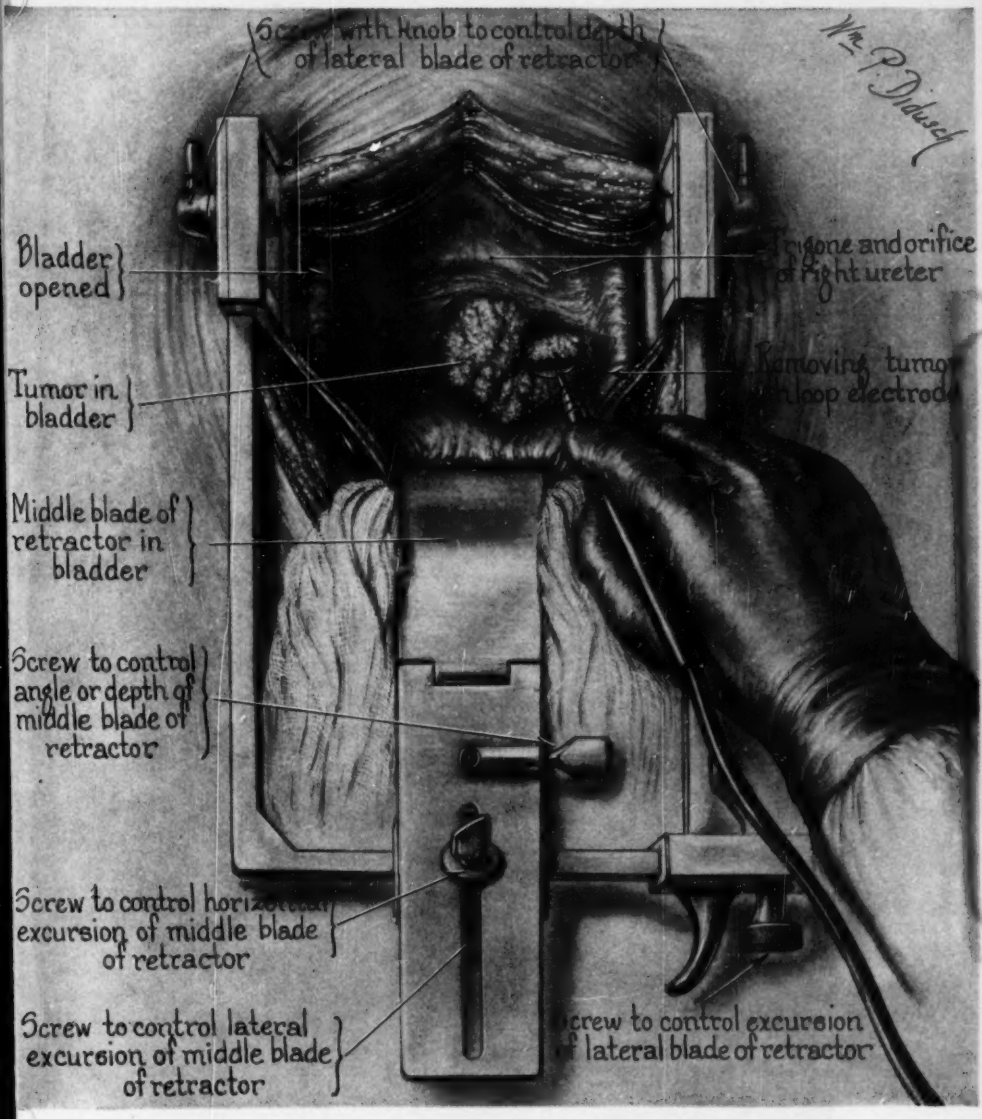
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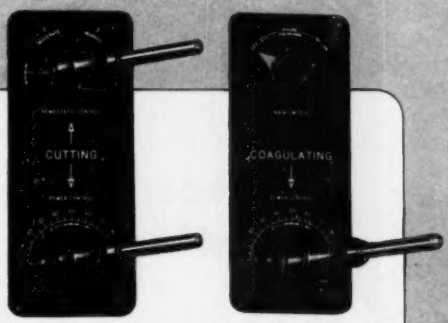

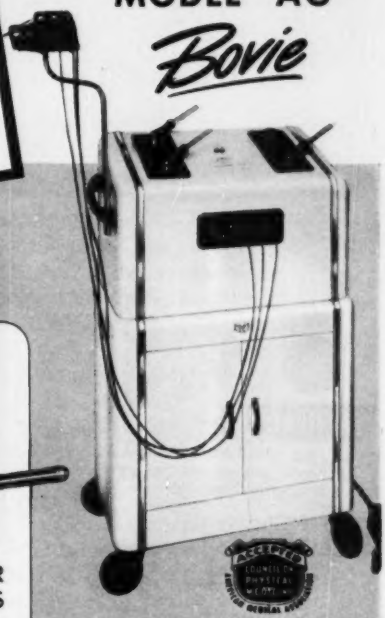

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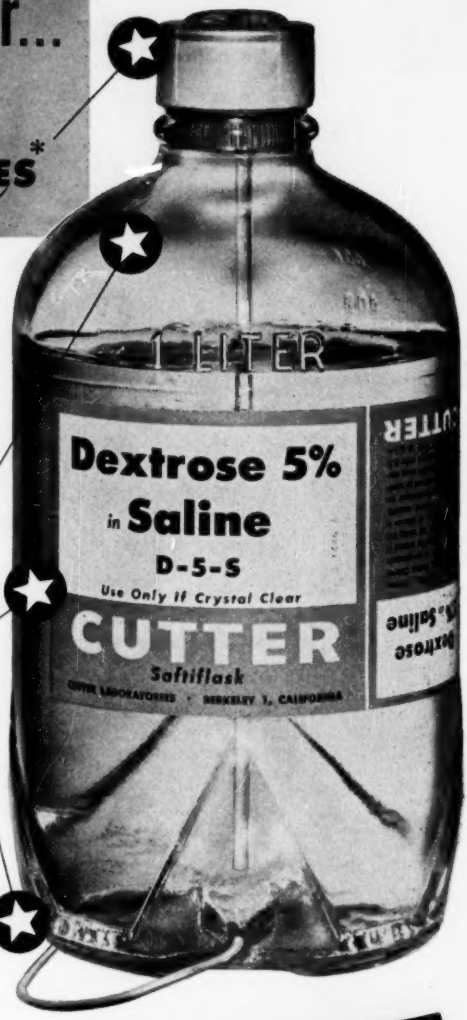

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TREATMENT OF TRAUMATIC HERNIA OF THE DIAPHRAGM

CONRAD R. LAM, M.D.
DETROIT

HAVING in mind the large number of serious accidents which are associated with fast transportation and large scale heavy industrial activity, one would expect to see a considerable number of diaphragmatic hernias along with the abdominal traumas, fractures of the pelvis, spine and ribs and other injuries involving the trunk. Actually, such is not the case, and a review of the surgical experience with hernia of the diaphragm at the Henry Ford Hospital during the past ten years has revealed that acute traumatic hernia of the diaphragm has been diagnosed only three times. During the same period, 206 fractures of the pelvis were indexed. The obvious conclusion is that the diaphragm is a hardy structure which is remarkably resistant to disruption.

The three acute hernias were repaired immediately, but not before one of them became complicated with a perforation of the incarcerated stomach. Although it would appear that the logical treatment of the injury is prompt surgical correction, 2 elderly patients herein reported on had received different advice, with the result that they were obliged to tolerate the presence of long lengths of gastrointestinal tract in their thoracic cavities for periods of five and ten years respectively. Each of the following 5 case histories presents some points of interest, and the symptoms outlined are probably representative of those which may be expected in other acute and chronic cases.

CASE 1.—J. H. was a 49 year old man who was admitted to the Henry Ford Hospital on Oct. 15, 1941. Four days earlier he had been hit by an automobile, a fender striking the right upper quadrant of the abdomen. He was taken to another hospital, where fluoroscopy showed the stomach to be above the diaphragm. He had relatively minor complaints, and the only positive physical signs were hyporesonance in the lower left region of the chest posteriorly and prominent peristaltic sounds in the same area. Roentgenograms confirmed the diagnosis of diaphragmatic hernia. For reasons which are not now apparent, the operation was delayed until October 31. The repair was done by Dr. B. F. Hoopes, resident surgeon, with my assistance. The left thoracic cavity was entered through the seventh interspace in the manner described under the section on operative technic. There was a large rent in the diaphragm extending from the dome to the esophageal hiatus. Most of the stomach and a considerable quantity of omentum were herniated. These were reduced without difficulty, and the defect in the diaphragm

From the Division of General Surgery of the Henry Ford Hospital.

was repaired with a single layer of interrupted heavy silk sutures. The thoracic wall was closed after the placement of an intercostal tube for underwater drainage.

On November 7, 100 cc. of serosanguineous fluid was aspirated from the tube, and culture of this revealed Staphylococcus aureus. Four days later, frankly purulent material escaped. Daily irrigations were carried out until November 24, when the tube was removed. A barium meal on November 26 showed that all the stomach was beneath the diaphragm, and the patient was permitted to leave the hospital. During the outpatient follow-up, it was observed that the tube sinus was closed on December 13, but an abscess appeared early in January, and after this was opened there was persistant drainage of pus. On March 2 the sinus tract was unroofed and two sequestrums were removed from an abscess cavity near a rib. The wound did not heal, and the sinus was again explored on July 19. It was necessary to resect a considerable length of rib to expose an abscess cavity which lay above the diaphragm and which contained several looped heavy silk sutures, obviously those which had been used to repair the defect in the diaphragm. The wound was packed open but healed again, with sinus formation. It was explored for the third time on December 29, when two more silk sutures were removed. After numerous outpatient dressings, the wound finally healed on May 3, 1943.

The patient was not seen until May 17, 1949, when he presented himself with the complaint of difficulty in eating which had been present for a few weeks. He had noted a gurgling sensation in the left upper quadrant of the abdomen. Auscultation revealed abnormal peristaltic sounds in the left lower region of the chest, and roentgenograms with barium showed a large part of the stomach back in the chest. Operation was carried out on June 6. The lowest intact rib, thought to be the eighth, was removed subperiosteally. An incision through the bed of this rib entered the abdominal cavity. The stomach and a considerable portion of the colon were seen to be above the diaphragm, entering at the site of the original hernia. It appeared that these organs had been in the chest for a long time, because sharp dissection was necessary to free them from the edge of the diaphragm. The colon was extricated first. During the operative maneuvers about the stomach, the escape of gastric contents was noted. The defect was found to be in an area of induration where the edge of the diaphragm pinched the stomach, and an actively ulcerating process was suggested. The opening was closed by imbrication with silk sutures. The rent in the diaphragm was repaired with interrupted silk sutures so that the suture line lay in a transverse direction. Several of the sutures passed through the pericardium. The postoperative course was without incident, and the patient was discharged on June 22 after roentgenograms showed the stomach to be maintained below the diaphragm.

It is assumed that the recurrence was due mainly to the factor of infection, which was followed by sequestration of the diaphragmatic sutures. Penicillin might have prevented the infection. The intercostal catheter probably did mischief as a foreign body and encouraged infection instead of serving a useful function as was intended.

CASE 2.—F. F. was a 55 year old man who was admitted at 2:55 a.m. on April 16, 1944, after an accident which had occurred twenty-five minutes before. He had been riding in the back seat of a car which collided with another, so that he was thrown against the front seat. He complained of extreme pain in the upper area of the abdomen. The respirations were short, rapid and labored. There was mild cyanosis. The pulse was of good quality, with a rate of 96 to the minute. Examination of the chest was difficult because of grunting, but dulness to the sixth interspace on the left and absence of breath sounds were described. The heart sounds were distant. The entire abdominal wall was rigid, but tenderness was pres-

ent only in the epigastrium. There was bony deformity of the right forearm. The tentative diagnosis was perforated abdominal viscus, hernia of the diaphragm and fracture of the bones of the forearm. Roentgenograms showed an area of increased density in the lower left lung field and a shift of the mediastinum to the right. A Levin tube was inserted in the stomach, and another roentgenogram of the chest revealed that the stomach was definitely above the diaphragm.

The patient had great difficulty breathing even in oxygen, and it was obvious that prompt intervention was imperative. Operation, by Dr. Kenneth Warren, resident surgeon, assisted by me, was begun at 2:45 p.m., about twelve hours after the accident. The cyanosis was relieved as soon as positive pressure anesthesia was administered. The left region of the chest was entered through the seventh interspace, and it was found that almost all the stomach, a large portion of the transverse colon, a segment of small bowel and most of the omentum were above the diaphragm. There was a large rent measuring about 6 inches (15 cm.) in the left leaf of the diaphragm extending from the esophageal hiatus laterally and posteriorly to a point beyond the apex of the dome. The abdominal viscera were reduced without difficulty, and the opening was closed with one layer of figure-of-8 sutures of heavy silk. The condition of the patient after the operation was greatly improved. Fluid was aspirated from the left side of the chest on several occasions, and open reduction of the radius and ulna was done on May 11 with the patient under general anesthesia. He was discharged on May 24, and two months later had no complaints referable to the chest. Efforts to obtain a follow-up in 1949 were unsuccessful.

This report illustrates the value of early operation in certain cases of traumatic diaphragmatic hernia. It was the opinion of several observers that this man's condition on the first day was so precarious that surgical intervention was inadvisable. Actually his difficulty was chiefly respiratory in nature, a condition which was not likely to improve with any measures short of straightforward surgical treatment.

CASE 3.—M. K. was a 62 year old woman who was admitted to the medical service on Sept. 13, 1945. She complained of gaseous indigestion of four months' duration, associated with colicky pain in the right upper quadrant, which usually occurred in the evening. Two weeks before there had been an unusually severe attack of pain, with which there were nausea and vomiting. She had been admitted to another hospital and had been discharged with the diagnosis of disease of the gallbladder. At this time the patient was acutely ill, with malnutrition and dehydration. The first examiner described the right side of the diaphragm as "somewhat high but with fair excursion." An ovoid mass at the right costal margin was described and a provisional diagnosis of subsiding acute cholecystitis was made. She improved under symptomatic treatment, and further gastrointestinal studies were carried out. Roentgenograms of the stomach after a barium meal showed that a large portion was upside down in the right side of the chest (fig. 1*A*). Loops of gas-filled colon could also be seen in the chest. A barium enema showed the colon reaching almost to the apex of the right hemithorax (fig. 1*B*).

A review of the patient's past history revealed that she had been in an automobile accident in 1936 and a number of ribs on the right had been fractured. She had noticed some shortness of breath since that time, although the gastrointestinal symptoms had only recently become prominent. It seemed certain that she had had a large traumatic hernia of the right side of the diaphragm for nine years without major symptoms until the current episode. Because she was feeling well again, she was discharged for observation and symptomatic treatment. During the next ten months she had few complaints other than shortness of breath.

She was readmitted on Aug. 22, 1946, because of recurrence of gastrointestinal symptoms. Four weeks earlier she had awakened with severe cramping pain. She was nauseated but could not vomit. She was hospitalized elsewhere for ten days, without improvement. She continued to have attacks of pain and had to sleep sitting up, although the rumbling of gas in her chest kept her awake most of the time. After ten days of further conservative treatment, operation became mandatory because it appeared that acute intestinal obstruction had developed. The procedure was carried out as an emergency on the afternoon of August 31. The right region of the chest was entered through the eighth interspace, the eighth rib being transected at the site of the old fracture. Almost the entire right hemithorax was occupied by abdominal organs. These included a large amount of small bowel, the transverse colon, all the stomach and the omentum. There were a number of adhesive bands extending from the lung to the thoracic wall, and about 18 inches (45.7 cm.) of small bowel was strangulated through one of these. After release of the adhesion, the circulation in the segment improved and peristalsis appeared. Herniation had occurred through an opening measuring

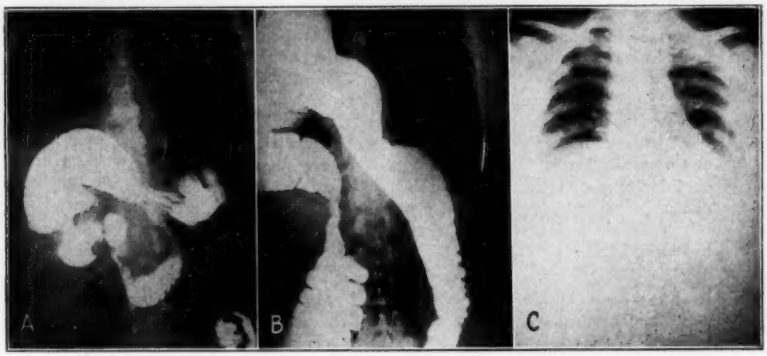

Fig. 1.—Roentgenograms in case 3. *A*, barium meal showed stomach upside down in the right side of the chest. Gas-filled loops of colon can be seen above. *B*, barium enema showed further encroachment on the lung by the colon. *C*, postoperative roentgenogram of chest.

approximately 10 cm. in diameter adjacent to but not involving the esophageal hiatus. The viscera were reduced with considerable difficulty, the reduction being in the following order: small bowel, omentum, colon and stomach. The defect in the diaphragm was closed with one layer of silk sutures, a portion of the thickened pulmonary ligament being used for the medial part of the repair. Postoperative roentgenograms showed that reduction was maintained (fig. 1 *C*). Three years later the patient reported that she was in perfect health.

The preoperative history of this patient has been given in some detail because it illustrates the futility of attempts at conservative treatment. The risks of definitive surgical correction of these hernias are certainly well below those of the late complications which are almost inevitable.

Case 4.—A. K., was a 19 year old boy who was admitted on Jan. 15, 1948 in an unconscious state after being hit by an automobile while riding a motorcycle. Preliminary examination revealed a laceration of the scalp, deformity of the left

wrist, a laceration of the left knee and a sucking wound of the left anterior region of the chest. Roentgenograms showed a fracture of the occipital area of the skull, a fracture dislocation of the left wrist, fracture of the left radius and ulna, a comminuted fracture of the patella, fracture of the seventh rib on the left and questionable elevation of the left side of the diaphragm. Two days later the roentgenogram of the chest showed 50 per cent collapse of the left lung and what appeared to be the stomach above the diaphragm (fig. 2*A*). It was planned to repair the traumatic diaphragmatic hernia in about a week, as soon as recovery from the head injury was more complete and after the various fractures had been treated in a more definitive way. A Levin tube was placed in the stomach, and he was permitted to take fluids by mouth. Vomiting occurred whenever the suction was discontinued, hence the only fluids retained were given intravenously. On January 23 barium was put in the stomach, and it was evident that the entire stomach was in the chest. Six hours later no barium had left the stomach. Shortly after this, the patient had a coughing spell, and there was a gush of blood-tinged, foul-smelling fluid from the puncture wound on the anterior wall of the chest. Perforation of the

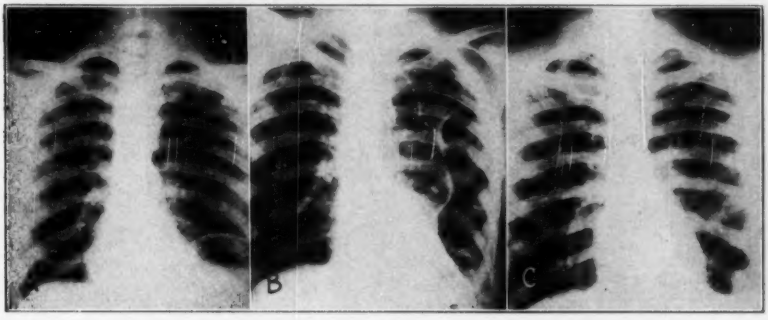

Fig. 2.—Roentgenograms in case 4. *A*, stomach containing air and fluid level above diaphragm on left side. *B*, appearance of chest after drainage of empyema which followed perforation of the stomach. *C*, final appearance of chest.

stomach was suspected and was proved after methylene blue was given by mouth. Operation was carried out by Dr. John Timmons, resident surgeon, assisted by me. There was a large amount of putrid, semiliquid material in the left pleural cavity which was colored with methylene blue and barium. It was evident that the entire stomach lay above the diaphragm, coming through a rent in the dome. The general circulation of the stomach appeared to be unimpaired. There was a punched-out ulcer, 0.75 cm. in diameter, on the greater curvature of the stomach. The puncture wound of the thoracic wall could be palpated from within and was in the fifth interspace. The left lung was almost entirely collapsed and was covered with a dirty gray exudate.

The perforation of the stomach was closed with three silk sutures. The stomach was reduced after the defect in the diaphragm had been extended laterally, after which the diaphragmatic opening was closed with O chromic surgical gut sutures. Silk was not used because of the infection which was obviously present and the previous experience in case 1. A Pezzer catheter was placed through an intercostal stab wound. The lung was decorticated as well as possible, but complete expansion

was not obtained at this time. His convalescence was slow because of the infection in the chest. Frank empyema developed which was treated by rib resection and open drainage (fig. 2 *B*), followed by several weeks of closed drainage. He was discharged on May 27. Progress roentgenograms a year later showed good expansion of the lung and no evidence of recurrence of the hernia (fig. 2 *C*).

This case report emphasizes the emergency nature of certain herniations of the stomach in which there is obstruction of outflow of the stomach by torsion or pressure. A reasonably prompt operation had been planned, but the early evidence of pyloric obstruction should have been adequate warning of the danger of perforation.

CASE 5.—C. H. was a 62 year old man who was admitted on June 27, 1949. In 1944 he was in an automobile accident in which he sustained a broken left wrist, two broken ribs on the left and a rupture of the left side of the diaphragm. He was told at that time that there was only a 50 per cent chance that the hernia could be repaired successfully. He had had no major digestive disturbances during the five year period, being bothered chiefly by shortness of breath. Roentgenograms showed the left hemithorax to be almost entirely filled with abdominal viscera

Fig. 3.—Roentgenograms in case 5. *A*, roentgenogram of chest showing gas-filled stomach almost up to the aortic arch. *B*, stomach after barium meal. *C*, final appearance of chest after operation.

(fig. 3 *A* and *B*). Operation was performed on June 27. The chest contained the entire stomach, most of the colon and a long length of small bowel. The opening in the diaphragm extended from the dome toward the esophageal hiatus. The viscera were replaced with great difficulty and only after all possible use was made of tubes in the stomach and colon for the removal of gas. A T-shaped closure of the diaphragmatic opening was carried out. A postoperative roentgenogram on September 2 showed no sign of recurrence and good expansion of the lung which had been compressed for five years (fig. 3 *C*).

OPERATIVE TECHNIC

A Levin tube is passed through the nose to the stomach. If the colon is known to be herniated, a rectal tube may also be of some value to assist in the deflation of the viscus. Adequate anesthesia and the subsequent expansion of the compressed lung can best be obtained with the use of an endotracheal tube. A cannula is placed in a saphenous

vein for the administration of blood during the operation. The patient is placed on the appropriate side, and a curving incision is made over the seventh interspace (fig. 4). It extends from near the costal margin to a point just lateral to the spinous processes. The latissimus dorsi muscle is transected, as are any slips of the serratus anterior muscle which are present. The erector spinae tendon is retracted from the

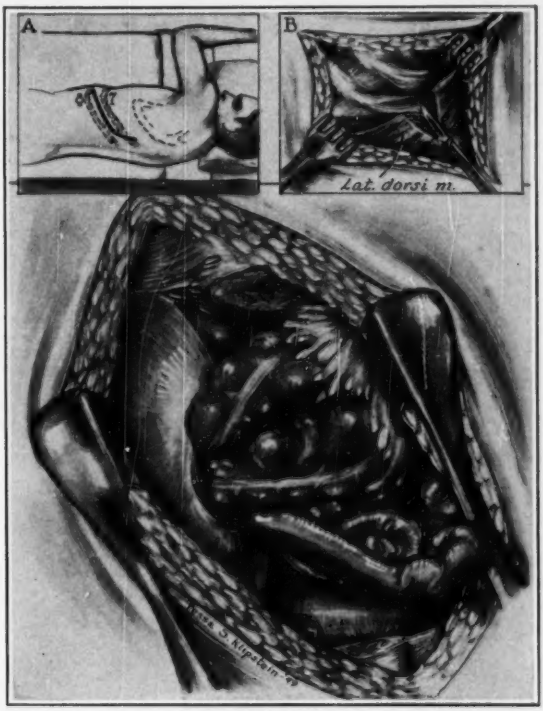

Fig. 4.—Steps in exposure of traumatic hernia of the diaphragm.

eighth rib, and this rib is transected subperiosteally medial to its angle. The intercostal muscles and pleura lying between the seventh and eighth ribs are then cut with a scissors, the incision being kept near the upper edge of the lower rib in order to avoid injury to the seventh intercostal nerve and vessels above. Adequate exposure is then easily maintained with self-retaining retractors. The herniated organs are identified, the edges of the diaphragmatic opening are grasped with Allis forceps

and reduction is begun (fig. 5). If motion of the diaphragm is a hindrance, the phrenic nerve could be conveniently crushed or blocked with procaine hydrochloride. However, in the 5 cases reported above there was no motion of the diaphragm during the operative procedure because of the excellent anesthesia which was present, and the nerve was not disturbed in any instance. Others [1] have advised that the nerve

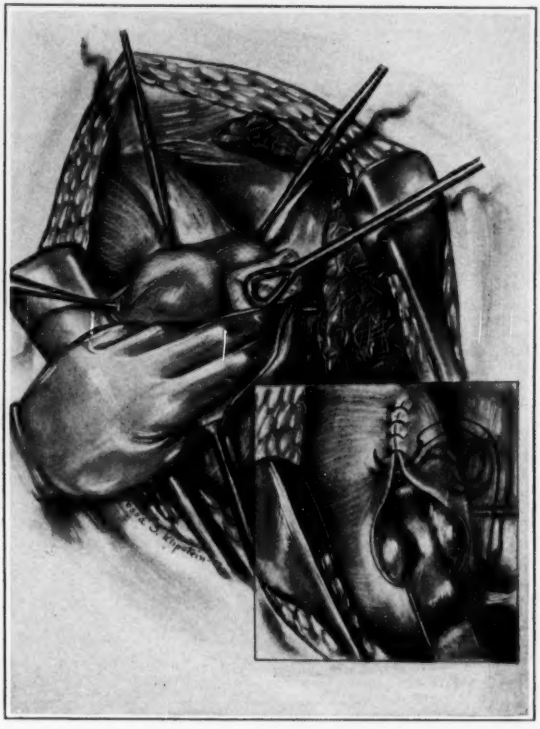

Fig. 5.—Reduction of viscera and closure of the hernia.

be crushed routinely with the idea that healing is facilitated by putting the muscle at rest. In the cases of acute hernia, reduction should be comparatively easy. However, with the two hernias of long standing reported on (cases 3 and 5) reduction was extremely difficult, and

1. Hughes, F., and others: Traumatic Diaphragmatic Hernia, J. Thoracic Surg. **17**:99, 1948.

there were times when it appeared that the abdominal cavities would not accept the replacement of the viscera. During the attempts at reduction, the restraints over the patient were checked to see that there was no pressure on the abdomen, the anesthesia was deepened and suction was applied to the gastric and rectal tubes. Probably per-

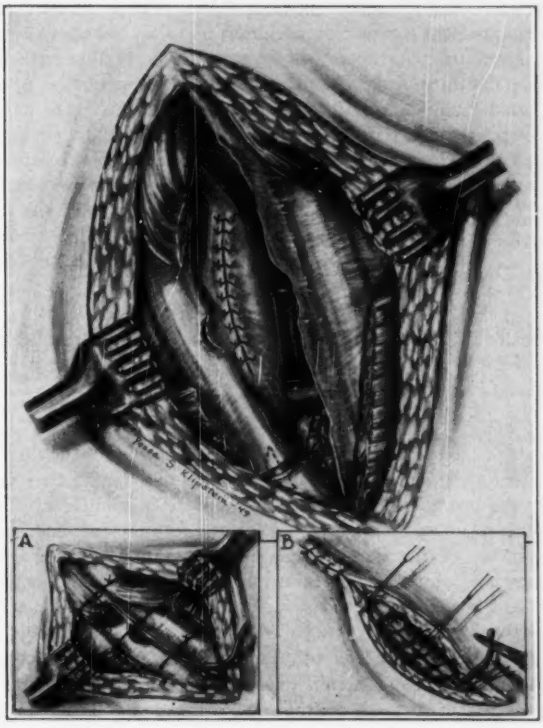

Fig. 6.—Steps in the closure of the thoracic wall after repair of diaphragmatic hernia. Note the small autogenous intramedullary peg in the transected eighth rib. The catheter is withdrawn when no more air can be removed from the chest after closure of the skin.

sistence is the most important factor. In both of these cases the small bowel was reduced first, followed by the omentum, colon and stomach.

All these diaphragmatic defects were repaired by a one layer closure, heavy silk being used except in the instance noted, when chromic surgical gut was chosen because of the severe infection, due to the

perforated stomach, which was present. They were sutured in the direction which permitted closure with the least tension, and in 1 case a T-shaped suture line resulted. After the repair of the hernia, the lung is expanded to fill the thorax if possible. This may be facilitated by the release of adhesions or even small decortication procedures. One hundred thousand units of penicillin dissolved in 10 cc. of sodium chloride solution is sprayed in the chest. The cut edges of the transected eighth rib are held together by the insertion of an intramedullary bone peg removed from its upper edge, after the suggestion of Klassen [2] (fig. 6). The ribs are held together by the use of periosteal sutures of heavy braided silk or no. 3 chromic surgical gut. A catheter is left protruding from the thoracic cavity for the removal of air after the closure of the skin. The muscles are approximated in two layers with a continuous suture of no. 1 chromic surgical gut or interrupted silk sutures. The edges of the skin are coapted with interrupted silk sutures, and the pneumothorax is reduced by suction on the catheter while the anesthetist increases the positive pressure, after which the catheter is removed.

During the first few postoperative days, the patients in this series were treated with continuous gastric suction. Early ambulation was encouraged. Prophylactic doses of penicillin were given for a week in the uncomplicated cases.

SUMMARY

Although the surgical problem in traumatic hernia of the diaphragm would seem to be simple, there may be some question of the optimum time for the operation. Early operations were imperative in 2 of the cases reported, once because of respiratory distress and once because of perforation of the incarcerated stomach. In another patient an emergency procedure had to be carried out because of strangulation of the small bowel in a hernia which had been present for ten years. Surgical repair within a few days of the accident would appear to be indicated. Although rare in proportion to the number of accidents, traumatic diaphragmatic hernia may be discovered in patients who are relatively asymptomatic by the timely use of the barium meal and enema. The technic of transthoracic repair has been described.

2. Klassen, K. P.: Medullary Pegging in Thoracotomy Incisions, J. Thoracic Surg. **18**:90, 1949.

PATTERNS OF ELECTRICAL SKIN RESISTANCE FOLLOWING SYMPATHECTOMY

JESSE E. THOMPSON, M.D.*
BOSTON
NICHOLAS A. BROSE, M.D.
PROVIDENCE, R. I.
AND
REGINALD H. SMITHWICK, M.D.
BOSTON

SINCE the psychogalvanic reflex, or Fere's phenomenon, was first described, in 1888,[1] there has been a continued and increasing interest in the study of the electrical resistance of the skin, first in Europe and since the 1920's in this country. For over twenty years the investigations of Richter [1] have served as the basis for studies of skin resistance in the United States. Used first by psychiatrists in an attempt to characterize certain psychopathic states, the electrical resistance of the skin has become important to surgeons dealing with the nervous system, particularly to those dealing with the sympathetic nervous system and with injuries of the peripheral nerves.

From the Surgical Service, Massachusetts Memorial Hospitals, and the Department of Surgery, Boston University School of Medicine.

* Trainee, National Cancer Institute.

1. (*a*) Richter, C. P.: Physiological Factors Involved in the Electrical Resistance of the Skin, Am. J. Physiol. **88**:596-615, 1929; (*b*) The Sweat Glands Studied by the Electrical Resistance Method, ibid. **68**:147, 1924; (*c*) A Study of the Electrical Skin Resistance and the Psychogalvanic Reflex in a Case of Unilateral Sweating, Brain **50**:216-235, 1927; (*d*) The Electrical Skin Resistance: Diurnal and Daily Variations in Psychopathic and in Normal Persons, Arch. Neurol. & Psychiat. **19**:488-508 (March) 1928; (*e*) Resistance of the Skin, Bull. Johns Hopkins Hosp. **45**:56-74, 1929. (*f*) Richter, C. P., and Woodruff, B. G.: Changes Produced by Sympathectomy in the Electrical Resistance of the Skin, Surgery **10**:957-970, 1941. (*g*) Richter, C. P., and Otenasek, F. J.: Thoracolumbar Sympathectomies Examined with the Electrical Skin Resistance Method, J. Neurosurg. **3**:120-134, 1946. (*h*) Richter, C. P.: Instructions for Using the Cutaneous Resistance Recorder or "Dermometer" on Peripheral Nerve Injuries, Sympathectomies, and Paravertebral Blocks, ibid. **3**:181-191, 1946; (*i*) Cutaneous Areas Denervated by Upper Thoracic and Stellate Ganglionectomies Determined by the Electrical Skin Resistance Method, ibid. **4**:221-232, 1947.

"The resistance offered by the body to the passage of a delicate constant current is localized almost entirely in the skin. This is shown quite conclusively by the fact that a minute puncture through the skin causes the resistance to drop from any level, however high, practically to zero." [1c] The effects of the various structures in the skin on resistance and the variations in different persons in different parts of the body at different times of day and in different states such as walking and sleeping have been studied.[1a] Though all factors are not completely understood, the single most important factor involved is moisture, which in turn is dependent on the activity of the sweat glands. Profuse sweating causes the resistance to be low, ranging from 200,000 to 20,000 ohms. Decreased or absent sweating causes the skin resistance to be extremely high, ranging up to several million ohms.

The secretion of sweat is largely under the control of the sympathetic nervous system, and as with other sympathetic nerves, the majority of sweat fibers pass out of the spinal cord with the anterior roots, synapse in sympathetic ganglions and then join the peripheral nerves to course distally with them to their destination. Hence anterior rhizotomy, peripheral nerve section and surgical or chemical sympathectomy will cause sudomotor paralysis of the denervated area and a marked increase in the electrical skin resistance. It is not thought that the parasympathetic system innervates the sweat glands directly. In contrast to the other organs innervated by the sympathetic nervous system, however, which have epinephrine or epineprine-like substances as the neurohumoral mediators, the sweat glands respond to acetylcholine under normal physiologic activity and to injections of pilocarpine and furfuryl trimethylammonium iodide (furmethide®); they are thus sympathetic cholinergic effectors.

The factors affecting secretion of sweat in man have been studied in detail by List and Peet,[2] and an excellent review of the entire subject of the physiology of sweating has recently been written by List.[3] It is not within the scope of this paper to discuss the subject in any further detail.

Because of the recent widespread application of sweating tests to clinical surgery, convenient and simple methods of study have been

2. List, C. F., and Peet, M. M.: Sweat Secretion in Man: I. Sweating Responses in Normal Persons, Arch. Neurol. & Psychiat. **39**:1228-1237 (June) 1938; Sweat Secretion in Man: II. Anatomic Distribution of Disturbances in Sweating Associated with Lesions of the Sympathetic, Nervous System, ibid. **40**:27-43 (July) 1938; Sweat Secretion in Man: III. Clinical Observations on Sweating Produced by Pilocarpine and Mecholyl, ibid. **40**:269-290 (Aug.) 1938; Sweat Secretion in Man: IV. Sweat Secretion of the Face and Its Disturbances, ibid. **40**:443-470 (Sept.) 1938.

3. List, C. F.: Physiology of Sweating, Ann. Rev. Physiol. **10**:387-400, 1948.

imperative. Richter [1b] first measured sweating and lack of sweating by electrical methods which measured skin resistance by employing nonpolarizable electrodes and a string galvanometer. He and his colleagues have gradually developed simpler, more accurate and more convenient pieces of apparatus, resulting in an instrument called a "portable neurodermometer," [4] recording qualitative but not quantitative readings. An earlier Richter instrument, not so compact as the one mentioned, permitted quantitative readings to be taken. A "dermohmmeter" has been devised by Jasper [5] which gives quantitative readings and has a wide range of resistance. Ray and Console [6] have also recently devised a dermometer giving quantitative readings.

Many nonelectrical methods for measuring sweating responses have been in use for years. A popular one has been the Minor starch-iodine test, used extensively by List and Peet,[2] depending on color changes in the presence of moisture for its end point. The test used by Roth [7] employed cobalt chloride and its color changes to test sweating areas. Guttman [7a] has used a quinizarin test, and Silverman and Powell [7a] have used a mixture of iron salts and tannic acid to produce an ink reaction in the presence of moisture. A method using prisms has recently been devised by Netsky and Walker.[8] In general, the electrical skin resistance method for studying sweating responses has been simpler, more convenient and much more accurate than tests employing color changes, and most recent series of investigations [9] have been carried out by this method.

The important clinical application of the presence or absence of sweating has had to do with two main lines of surgical endeavor: (1) return of function following nerve suture in injuries of the peripheral nerves and (2) extent of the denervated areas following sympathectomy in all parts of the body. It is with the latter that this paper is concerned.

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4. Whelan, F. G., and Richter, C. P.: Electrical Skin Resistance Technic Used to Map Areas of Skin Affected by Sympathectomy and by Other Surgical or Functional Factors, Arch. Neurol. & Psychiat. **49**:454-456 (March) 1943.

5. Jasper, H.: An Improved Clinical Dermohmmeter, J. Neurosurg. **2**:257-260, 1945.

6. Ray, B. S., and Console, A. D.: Residual Sympathetic Pathways After Paravertebral Sympathectomy, J. Neurosurg. **5**:23-50, 1948.

7. Roth, G. M.: The Distribution of Anhidrosis Following Interruption of Various Sympathetic Pathways in Man, Surgery **2**:343-349, 1937.

7a. Cited by List.[3]

8. Netsky, M. G., and Walker, A. E.: Innervation of Sweat Glands of Upper Extremity: Newer Methods of Studying Sweating, Tr. Am. Neurol. A. **72**:145-148, 1947.

9. Smithwick, R. H.: Surgical Intervention on the Sympathetic Nervous System for Peripheral Vascular Disease, Arch. Surg. **40**:286-306 (Feb.) 1940. Richter and Otenasek.[1g] Richter.[11]

The anatomic connections between the central nervous system and the sympathetic nervous system are described by White and Smithwick [10] and by Kuntz.[11] The concept of the nature of the cutaneous sympathetic innervation is that the segmental postganglionic innervation corresponds closely with sensory dermatomes, while the preganglionic outflow from the central nervous system is over the white rami of the thoracolumbar nerves from the first dorsal to the second lumbar or possibly the third lumbar region and is therefore diffuse in nature. Data on anatomic dissections [12] and surface temperature have been inadequate to establish definitely the exact sympathetic outflow to various parts of the body, while determinations of electrical skin resistance have offered an ideal and accurate method of ascertaining denervated areas after surgical procedures and hence of throwing light on the problem by a physiologic method.

The purpose of this paper is to describe our findings, with the use of electrical skin resistance methods, after sympathectomies on all parts of the body, to point out certain limitations of the method when used as a check on the extent of sympathectomy and to discuss certain unusual aspects of sudomotor innervation which the study has brought to light.

METHOD AND MATERIALS

Studies on electrical skin resistance were carried out on 177 patients in whom various types of sympathectomies had been done, i. e., dorsal, extensive transthoracic, Peet, lumbodorsal, total and lumbar sympathectomies. The total number of sides or extremities involved was 377 (table 1). These operations were done for a variety of disorders including hypertension, peripheral vascular disease, angina pectoris, tachycardia, abdominal pain, hyperhidrosis, coarctation of the aorta and causalgia. All the patients were operated on by one or another of us, so that standard technics and similar criteria for recognition of the various levels of ganglionectomy were used throughout.

Some of the patients were studied preoperatively to obtain base line data on the method, many were checked between stages of operations and all were studied after completion of sympathectomy procedures. The tests were done at least ten days, but usually twelve to fourteen days, postoperatively to eliminate the factor of hyperreactivity phenomena.

10. White, J. C., and Smithwick, R. H.: The Autonomic Nervous System: Anatomy, Physiology, and Surgical Application, ed. 2, New York, The Macmillan Company, 1941.

11. Kuntz, A.: The Autonomic Nervous System, ed. 3, Philadelphia, Lea & Febiger, 1945.

12. Gray, H.: Anatomy of The Human Body, edited by W. H. Lewis, ed. 24, Philadelphia, Lea & Febiger, 1942.

The studies of skin resistance were done over a period of nearly three years, and two separate groups were tested by two of us (J. E. T. and N. A. B.), each working independently of the other and not knowing the other's findings. The results obtained in the two separate groups checked well as far as resistance patterns were concerned. We consider this to be of importance because of conflicting reports in the literature in regard to the patterns obtained after supposedly similar sympathectomies.

All the tests were carried out with the neurodermometer setup described by Richter [1h] and manufactured by the A. R. Spartana Company of Baltimore. This portable machine consists of a microammeter measuring from 0 to 20 or 0 to 100 microamperes, a 4½ volt battery, a 1,000 ohm potential divider and a telephone plug socket with a jack switch. Two silver-plated phosphor-bronze or zinc electrodes are used, one being in the shape of an ear clip and the other a disk ½ inch

TABLE 1.—*Classification of Sympathectomies Performed*

Type of Sympathectomy	Number of Sides Tested		Number of Patients
Dorsal sympathectomy, D_2 and D_3	29		17
Extensive thoracic sympathectomy	36		19
Peet operation (dorsal splanchnicectomy)	6		4
Lumbodorsal splanchnicectomy	230		117
D_6 through L_1		122	
D_8 through L_2		88	
D_8 through L_3		19	
Total sympathectomy	20		10
Lumbar sympathectomy	16		10
Totals	337		177

(1.27 cm.) in diameter for exploring the skin surface. The machine is not calibrated to be read directly in ohms or to give quantitative measurements but merely indicates differences in skin resistance as the electrode is moved about. It is sensitive, however, and the differences in skin resistance under consideration are usually so great that the machine is entirely satisfactory for marking out areas of increased resistance after sympathectomy. The absolute resistance values in ohms vary tremendously from denervated to nondenervated areas, such as from 20,000 ohms in normal skin to 20,000,000 ohms or more in denervated areas. The machine indicates also whether an area is only partially denervated. We have, therefore, arbitrarily divided our readings into three groups: normal sweating or low resistance, slight sweating or moderate resistance and no sweating or high resistance.

The patient is placed in a hot room under blankets for fifteen or twenty minutes, or until he begins to sweat. Hot tea or acetylsalicylic acid may be administered, but pilocarpine and furmethide® are not used. The ear electrode is then covered with electrode paste and clipped

to one ear lobe, where a slight needle puncture wound of the lobe is made to eliminate local resistance. The electrodes are then connected to the neurodermometer, the movable electrode placed lightly against the skin and the current adjusted until the indicator moves entirely across the scale in nondenervated or sweating areas. When this obtains, the indicator does not move or moves only a few divisions on the scale in completely sympathectomized or high resistance areas. "Scout" readings of the entire body or of the extremity under consideration are then quickly taken to indicate the approximate lines of demarcation of differences in skin resistance. The areas of high and low resistance are then carefully mapped out by moving the electrode back and forth. Care must be taken not to have moisture on the electrode when it is moved from one area to another, for the reading is then inaccurate. The line of demarcation is marked with a skin pencil or other marking devices until the entire area or body is tested, and the areas so mapped out are then charted, as illustrated later. The lines of demarcation so obtained are sharp, as a rule, usually being within a strip 5 mm. wide.

TABLE 2.—*Numerical Classification of Skin Resistance Patterns Following Dorsal Sympathectomy, as Illustrated in Figure 1*

	A	B	C	D	E	F	G	H	Others	Total
Number of extremities or sides.....	6	2	2	6	3	4	2	1	3	29

DORSAL SYMPATHECTOMY

Patterns of electrical skin resistance were obtained on twenty-nine extremities in 17 patients subjected to sympathectomy of the second and third dorsal nerves. These patients were operated on for Raynaud's disease, hyperhidrosis, causalgia and other states of vasomotor imbalance. The operation performed was dorsal sympathectomy according to Smithwick's technic, in which the second and third dorsal ganglions are decentralized and enclosed in a silk cylinder, and the enclosed ganglions and trunk sewed into the wound outside the thorax. The second and third intercostal nerves in most instances were sectioned intraspinally and a 2 inch (5.08 cm.) segment of the nerves resected. Figure 1 shows the patterns of skin resistance obtained, and table 2 shows the number of cases in each group.

Figure 1 *A* shows the pattern obtained on six sides. There was complete denervation of both arms, the entire face to the hair line, the posterior cervical region to the hair line and the upper trunk through the third dorsal dermatome. The axillas were not denervated. The top of the head was not tested in any of the patients. Figure 1 *B* shows a similar pattern of skin resistance except that in the two extremities of this group the axillas were denervated. Figure 1 *C* exemplifies a

patient whose pattern is similar to the two mentioned but differs in that the central portion of the face continued to sweat. The axillas here were not denervated. Figure 1 *D* represents the pattern seen in six sides, where there was complete denervation of the arms, upper trunk and neck but no denervation of the face. The axillas remained undenervated. Figure 1 *E* is the pattern found in 3 cases and is similar to figure 1 *D*, the difference being that the lower two thirds of the face was completely denervated while the upper third was only partly denervated. Figure 1 *F* represents the findings in 2 patients in whom the

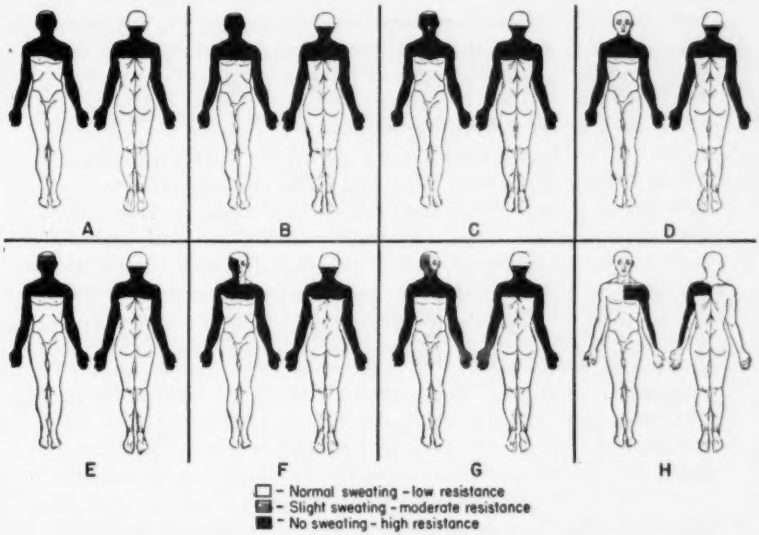

Fig. 1.—Patterns of skin resistance following dorsal sympathectomy (second and third dorsal nerves). *A*, axillas not denervated. *B*, similar to *A* except axillas denervated. *C*, central portion of face and axillas not derivated. *D*, entire face and axillas not denervated. *E*, upper third of face partially denervated; axillas not denervated. *F*, right side of forehead not denervated. Entire left side of face and neck and both axillas not denervated. Note the difference in the two sides. *G*, face partially denervated. Left arm and hand partially denervated in seventh and eighth cervical and the first dorsal dermatomes. *H*, denervation of chest wall and lateral aspect of arm only. Right side not operated on.

patterns of skin resistance differed on the two sides. One side showed normal sweating of the neck and face, while the other half was completely denervated except for the forehead. Figure 1 *G* is the pattern found in a patient in whom there was only partial denervation of the face, with no denervation in the upper half unilaterally and only partial

denervation of the arm and hand in portions of the seventh and eighth cervical and first dorsal dermatomes. Figure 1*H* represents one extremity showing an unusual pattern. The only demonstrable denervated areas were the upper part of the trunk, including the distribution of the third dermatome, and the arm in the distribution of the fifth and sixth dermatomes. None of the patients exhibited Horner's syndrome.

It appears that the preganglionic sudomotor outflow to the head may arise either entirely from below the first dorsal nerve and ascend in the sympathetic trunk to its destination (fig. 1 *A* and *B*), arise entirely from above the second dorsal nerve (fig. 1 *D*, *F* and *H*), or arise partially above the second dorsal and partially below the first dorsal nerve (fig. 1 *C*, *E*, *F* and *G*). Richter [11] has also described a partial denervation of the central portion of the face following dorsal sympathectomy.

In the majority of instances the hands and arms are completely denervated by sympathectomy of the second and third dorsal nerves. Figure 1 *G* and *H*, however, show that rarely anatomic variations are such that a portion of the outflow arises from other sources, presumably from above the second dorsal nerve since the trunk is sectioned surgically below the third dorsal nerve, thus preventing outflow from below reaching the arm. It is possible that a variant such as Kuntz's nerve could account for these findings in the cases in which the second and third intercostal nerves are not sectioned during the course of sympathectomy. A prefixed brachial plexus could conceivably be responsible for some of these variations also. Ray and others [13] noted a case in which the first dorsal nerve played a role in sudomotor activity in the arm. The remainder of their 16 patients showed no outflow from the first dorsal nerve, the outflow beginning at the second dorsal nerve in the majority and extending as far inferiorly as the tenth dorsal nerve. It is of interest to note the variations on the two sides in the same patient, as illustrated in figure 1 *F* and *G*.

A point of major interest is the fact that the axillas are usually not completely denervated. Richter [11] has described a similar finding. Connections with the sympathetic trunk from below the third dorsal nerve could account for this finding, but observations reported later render this hypothesis untenable. The question of other pathways to the axillas therefore arises to account for continued sweating. This will be discussed in the next section.

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13. Ray, B. S.; Hinsey, J. C., and Geohegan, W. A.: Observations on the Distribution of the Sympathetic Nerves to the Pupil and Upper Extremity as Determined by Stimulation of the Anterior Roots in Man, Ann. Surg. **118**:647-655, 1943.

EXTENSIVE THORACIC SYMPATHECTOMY

Studies of skin resistance were carried out on thirty-six sides of 19 patients after extensive transthoracic sympathectomy performed for the treatment of angina pectoris, tachycardia and hypertension. The extent of the ganglionectomy was usually from the first or second to the eleventh or twelfth dorsal ganglion inclusive. In some cases the inferior cervical ganglion was resected, and in others the lower limit of the excision was the eighth or ninth dorsal ganglion.

The results are shown in figure 2 and table 3. The usual pattern was that shown in figure 2 *A* and *B*, with complete denervation of the

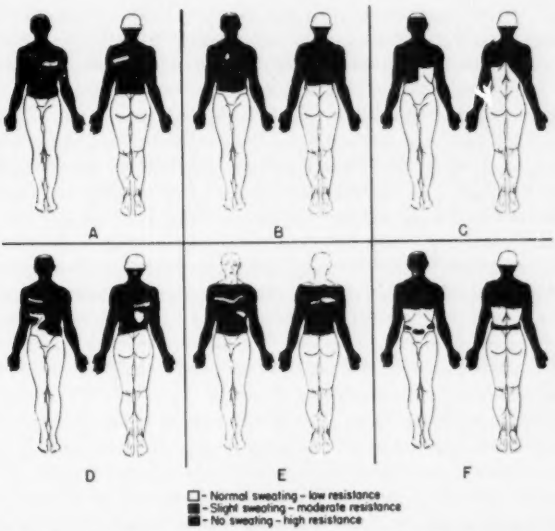

Fig. 2.—Patterns of skin resistance following extensive thoracic sympathectomy. *A*, bilateral removal of first through twelfth dorsal ganglions. No Horner's syndrome. *B*, bilateral removal of first through eleventh dorsal ganglions. Bilateral Horner's syndrome. Axillas not denervated. *C*, removal of inferior cervical ganglions through the ninth or tenth dorsal ganglion, right side; removal of inferior cervical ganglions through the eighth dorsal, left side. Bilateral Horner's syndrome. *D*, removal of inferior cervical ganglions through eleventh or twelfth dorsal, right side; removal of first through twelfth dorsal ganglions, left. Bilateral Horner's syndrome. *E*, bilateral removal of second through twelfth dorsal ganglions. No Horner's syndrome. Axillas not denervated. *F*, bilateral removal of first through tenth dorsal ganglions. Horner's syndrome on left.

TABLE 3.—*Numerical Classification of Skin Resistance Patterns Following Extensive Thoracic Sympathectomy, as Illustrated in Figure 2.*

	A	B	C	D	E	F	Others	Total
Number of extremities or sides.....	9	8	7	3	2	2	5	36

skin from the hair line to the level of the iliac crests, unless the lower limit of the ganglionectomy was higher than the eleventh or twelfth dorsal ganglion, in which case the lower limit of the denervated area was correspondingly higher. Both hands and arms were usually anhidrotic. There was almost invariably an area or strip of undenervated skin on one or both sides of the thorax, as seen in figure 2 *A, B, D, E* and *F,* varying in size and location but a constant feature of the pattern. The majority of these patients exhibited Horner's syndrome, but figure 2 *A* represents a group which did not exhibit Horner's syndrome even though the face, arms and chest were almost completely denervated. Figure 2 *C* illustrates a group in which the inferior cervical ganglions were removed as the upper limit of the resection; these patients constantly exhibited Horner's syndrome as well as complete denervation of the arms and chest. As with the usual dorsal sympathectomy (second and third dorsal ganglions), the axillas were usually not denervated in these extensive thoracic sympathectomies. This was true when the upper extent of the ganglionectomy was the first dorsal or the inferior cervical ganglion, and when the lower limit was the twelfth dorsal ganglion. Figure 2 *E* shows an undenervated face and neck after an extensive sympathectomy (second to twelfth dorsal nerves). As expected, Horner's syndrome was not present. Figure 2 *F* shows a patient who underwent bilateral denervation of the first to the tenth dorsal nerve. The right side of the face was only partially denervated, and Horner's syndrome was not present. The undenervated areas of the chest wall were particularly extensive. Ray and others,[13] by direct stimulation experiments, have shown variations in outflow to the arms and pupils on two sides of the same patient.

It is of interest that in some of the patients in whom the first dorsal ganglion was resected Horner's syndrome was not observed. This can be interpreted to mean that preganglionic fibers to the pupils in these patients arise from above the first dorsal ganglion, namely, in the inferior cervical ganglion or above it. Ray and others [13] have shown by direct stimulation of anterior roots during laminectomy that preganglionic innervation to the pupil travels through one or more roots and between the inferior cervical and the fourth dorsal ganglion. In the series of 10 cases studied, in only 1 was the origin in the inferior cervical ganglion, and then in conjunction with fibers from the first, second and third dorsal ganglions. In all at least one origin was in the first dorsal ganglion, and in 4 the origins were from the first and second dorsal ganglions only, the remaining pupils having a more extensive outflow from below in addition. Anatomic variations in the shape of the stellate ganglion encountered at the time of operation when this ganglion is divided to spare the inferior cervical portion may also account for the variations in the constancy of appearance of Horner's syndrome.

The axillas are usually not completely denervated after extensive thoracic sympathectomy. As seen in figure 2, there are also areas on

the wall of the chest which continue to sweat. These areas are not present after dorsal sympathectomy (second and third ganglions) when the nerve roots have been sectioned and the intercostal nerves removed. We have not sectioned the first dorsal motor root and so do not know whether this root contributes sweat fibers to the axilla. We have also not done extensive root sections below the third dorsal segment.

The problem of residual sympathetic activity following conventional sympathectomies has interested us for some time. Because of the constancy of the patterns found by us and by others, it appears unlikely that these areas could be the result of technical incompleteness. The pathway does not seem to be in the nerves of the vertebral canal, as described by van Buskirk,[14] because of the continued presence of sweating areas on the chest and thighs even after total sympathectomy. As will be discussed in a following section, Cone [15] has shown that anterior root section of the lower dorsal and upper lumbar nerves will abolish the sweating in areas on the thigh. Ray and Console [6] have also shown that the sweating in these areas can be abolished by the use of spinal anesthesia, anterior root section, procaine hydrochloride block or division of peripheral nerves or by giving tetraethylammonium chloride. It thus seems certain that these fibers do have ganglionic synapses before reaching their destinations. The problem resolves itself into the location of the ganglions, if they do lie outside the ganglionated sympathetic trunk. A recent report by Skoog [16] sheds light on this matter. He called attention to sympathetic structures termed "intermediate ganglia," which are distributed in the communicating rami to the spinal nerves. Onodi [17] in 1886 first mentioned ganglions in the rami communicantes of human embryos. Marinesco and Minea [17] confirmed this observation in 1908, noting small ganglions attached to the rami in lumbar or sacral ganglions. They pointed out that these ganglions were sympathetic in nature. In 1921 Hirt [17] introduced the term "intermediate ganglia" to describe these masses of tissue. Gruss [17] in 1932 found the ganglions in the lumbar region of fetuses, infants and adults. Wrete [16] studied the embryologic development of the intermediate ganglions and found them concentrated in two areas, near the brachial plexus and the lumbar plexus. He noted their sporadic occurrence in other segments. He

14. Van Buskirk, C.: Nerves in The Vertebral Canal: Their Relation to the Sympathetic Innervation of the Upper Extremities, Arch. Surg. **43**:427-432 (Sept.) 1941.

15. Cone, W. V., cited by Ray, B., and Console, A. D.: Residual Sympathetic Pathways After Paravertebral Sympathectomy, J. Neurosurg. **5**:23-50, 1948.

16. Skoog, T.: Ganglia in the Communicating Rami of the Cervical Sympathetic Trunk, Lancet **2**:457-460, 1947.

17. Cited by Goetz, R. H.: Collective Review: The Surgical Physiology of the Sympathetic Nervous System with Special Reference to Cardiovascular Disorders, Internat. Abstr. Surg. **87**:417-439, 1948, in Surg., Gynec. & Obst., Nov. 1948.

demonstrated a large but variable number of such ganglions in the lumbar rami of adults and pointed out that it is not impossible that these ganglion cells send postganglionic fibers to the nearby spinal nerve. Skoog [10] studied the cervical region in 5 adults and found the ganglions, varying in size from visible to microscopic masses of cells, in the rami of the cervical and first and second thoracic spinal nerves. Some lay very close to the spinal nerve or even within it. Their number varied from ten to nineteen. He assumed that these are motor ganglion cells and may receive their preganglionic supply (1) from the sympathetic trunk or (2) directly from the spinal nerve next to which they are lying. From our own observations combined with those of Ray and Console,[6] the latter possibility appears to be the correct one. The existence of

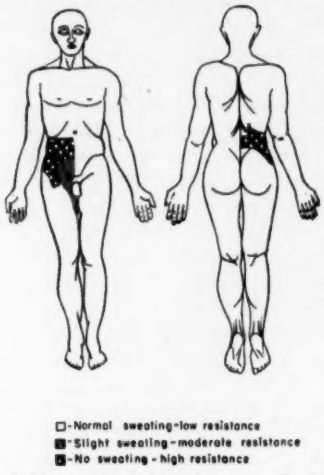

Fig. 3.—Pattern of skin resistance following removal of ninth through twelfth dorsal ganglions on the right side.

these intermediate ganglions would explain the failure to denervate completely certain areas after standard sympathectomies. This applies equally well to undenervated areas following lumbodorsal and lumbar sympathectomies, discussed in the next section, and to areas on the thoracic wall as mentioned previously.

PEET OPERATIONS

Studies of skin resistance were done on six extremities of 4 patients subjected to lower dorsal sympathectomy and splanchnicectomy, or the Peet operation, in which the eighth or ninth through the twelfth ganglion and the great splanchnic nerves were removed. These operations were done to relieve visceral pain. Figure 3 shows a typical denervation pat-

tern obtained, with complete denervation in the tenth to the twelfth dorsal dermatome and a partial denervation in the medial groin region. The legs were carefully studied for evidence of dorsal outflow to the limbs, but no definite areas of denervation could be outlined. In 1 case, however, there was slight reduction of sweating over the entire extremity. Studies of surface temperature [18] on the same extremities usually show no change in the preoperative and postoperative temperature curves; occasionally, however, there is slight warming of the limbs in both warm and cool environments postoperatively. These data indicate that the sympathetic outflow to the lower extremities from the dorsal region is only slight. This is also borne out by anatomic evidence in that the strand of sympathetic trunk connecting the twelfth dorsal to the lumbar ganglion is usually small compared with the size of the trunk above the twelfth dorsal and below the first lumbar ganglion. It is to be noticed

TABLE 4.—*Numerical Classification of Skin Resistance Patterns Following Lumbodorsal Splanchnicectomy, as Illustrated in Figures 4, 5 and 6*

	A	B	C	D	E	F	G	H	Others	Total
D8 through L1 (Fig. 4)										
Number of extremities	75	15	9	8	5	3	2	1	5	123

	A	B	C	D	Others	Total
D8 through L2 (Fig. 5)						
Number of extremities	67	11	5	1	4	88

	A	B	C	Others	Total
D8 through L3 (Fig. 6)					
Number of extremities	5	6	3	5	19

Total number of extremities 230
Total number of patients 117

also that the area of denervation is smaller than the dermatome distribution of ganglions removed, probably because of overlap.

LUMBODORSAL SPLANCHNICECTOMY

A. Removal of the Eighth Dorsal Through the First Lumbar Ganglion.—Studies of skin resistance were carried out on two hundred and thirty extremities in 117 patients subjected to lumbodorsal splanchnicectomy for the treatment of hypertension. Of these, one hundred and twenty-three extremities were denervated by removal of the eighth or ninth dorsal through the first lumbar ganglion and the great splannic nerves. Figure 4 illustrates most of the patterns observed, and table 4 shows the numerical distribution.

Figure 4 *A* shows the most frequently encountered pattern, it being found in seventy-five extremities. There was complete denervation from the eighth or ninth dorsal dermatome caudad, except for the anterior, medial and lateral regions of the thigh, which apparently con-

18. Thompson, J. E.: Unpublished data.

tinued to perspire in a normal fashion. Figure 4 *B* shows a pattern exhibited by fifteen extremities and is similar to figure 4 *A* except that the anterior region of the thigh was partly denervated. Figure 4 *C* is the pattern found in nine extremities and shows a complete denervation of the lower part of the trunk and a generalized partial denervation of the entire lower extremity, corresponding to a generalized outflow to all segments below the dorsal ones. Figure 4 *D* is the pattern seen in eight limbs and shows complete denervation in a band encircling the lower part of the trunk but leaving the extremities to sweat in a normal fashion, with no demonstrable denervation. Figure 4 *E* is the pattern found in

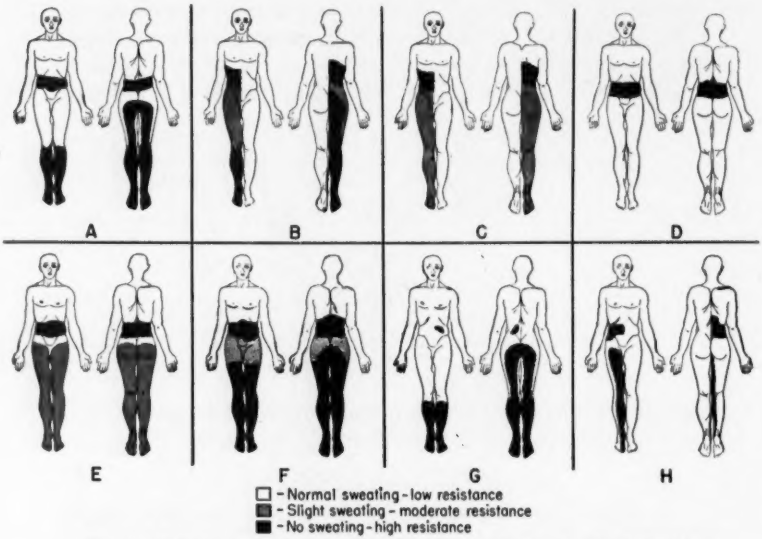

Fig. 4.—Patterns of skin resistance following lumbodorsal splanchnicectomy (eighth dorsal through first lumbar nerves). *A*, bilateral operation. Note normal sweating on anterior region of thigh. *B*, operation on right side; left side not operated on. *C*, operation on right side; left side not operated on. Note the diffuse effect of ablation of first lumbar ganglion. *D*, bilateral operation. Note similarity to *C*. *E*, bilateral operation. *F*, bilateral operation. *G*, bilateral operation. Contrast with *D*. *H*, operation on right side; left side not operated on. This pattern is unique.

five extremities and is a variant of figure 4 *C*, the difference being that the groin areas continued to sweat to an apparently normal degree. Figure 4 *F* is a curious pattern seen in three extremities. Here there was complete denervation of the trunk and legs below the ninth dorsal segment except for a band of partial denervation in the groin, upper anterior region of the thigh and twelfth dorsal and first and second

lumbar dermatomes posteriorly. Figure 4 *G* is the pattern seen in 2 instances. The lower part of the legs and the posterior region of the thighs were completely denervated, but the remainder of the legs and trunk, except for two isolated areas anteriorly and posteriorly, had normal skin resistance. Figure 4 *H* represents a curiosity seen in only 1 case. There was complete denervation of the lower part of the trunk and the anteromedial aspect of the entire leg but no denervation of the

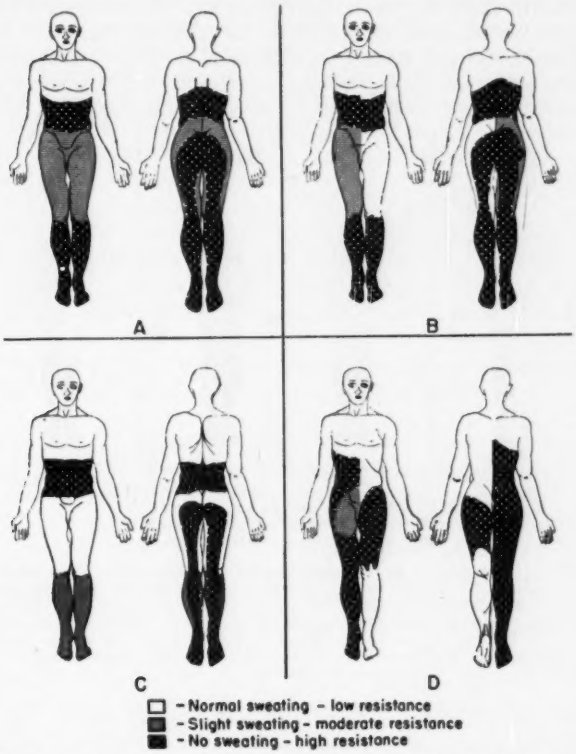

Fig. 5.—Patterns of skin resistance following lumbodorsal splanchnicectomy (eighth dorsal through second lumbar nerves). *A*, bilateral operation. Most common pattern observed. *B*, excision of eighth dorsal through second lumbar ganglions on left and of seventh dorsal through first lumbar ganglions on right. The left leg shows the second most common pattern. *C*, excision of eighth dorsal through second or third lumbar ganglions on right and of eighth dorsal through second lumbar ganglions on left. Note partial denervation on anterior lower region of the leg. *D*, operation on the right only. Left side not operated on. Note the denervated area on the left leg.

groin or the remainder of the leg in its lateral and posterior aspects or the buttocks.

B. Removal of the Eighth Dorsal Through the Second Lumbar Ganglion.—Studies of skin resistance were done on eighty-eight extremities denervated by lumbodorsal splanchnicectomy in which the eighth or ninth dorsal through the second lumbar ganglion and the great splanchnic nerves were removed. Figure 5 shows four of the patterns obtained, and table 4 shows their numerical distribution. Figure 5 *A* is the most common pattern, sixty-seven extremities exhibiting this. The entire lower part of the leg and posterior region of the thigh were completely denervated as well as the trunk up to the level of the eighth or ninth dorsal dermatome. The anterior, lateral and medial surfaces of the skin

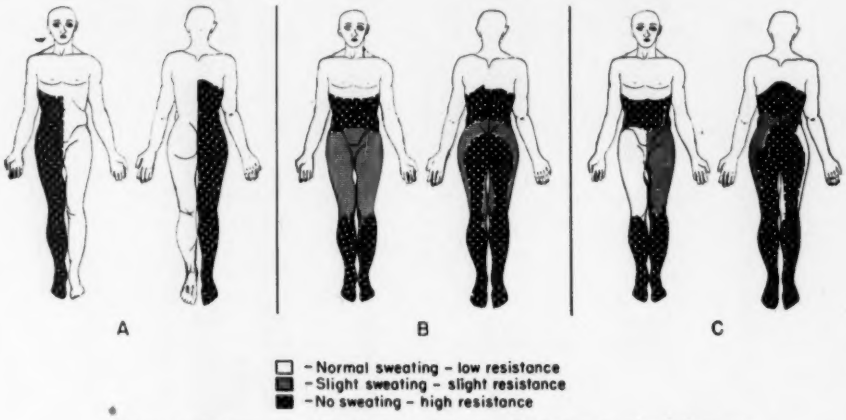

Fig. 6.—Patterns of skin resistance following lumbodorsal splanchnicectomy (eighth dorsal through third lumbar nerves). *A*, complete absence of sweating. *B*, excision of eighth dorsal through third lumbar ganglions on left side and of eighth dorsal through second lumbar ganglions on right side. Note the similarity of the two extremities. *C*, excision of eighth dorsal through third lumbar ganglions on right side and of eighth dorsal through second lumbar ganglions on left side. Note the apparently normal sweating on the right thigh.

of the thigh were only partially denervated, however. Figure 5 *B*, left, is the next most common pattern, eleven extremities exhibiting it. It is similar to figure 5 *A* except that the anterior part of the thigh apparently continued to sweat in a normal fashin. Figure 5 *C* is the pattern shown by five extremities. Here the lower end of the trunk and the entire posterior surface of the legs and soles of the feet were completely denervated, the anterior, medial and lateral surfaces of the lower part of the leg were partially denervated and the anterior, medial and lateral surfaces of the thigh were not demonstrably denervated. Figure 5 *D*

shows the pattern exhibited by 1 patient in whom the eighth dorsal through the second lumbar ganglion on the right side only were removed. The entire right half of the body from the ensiform cartilage inferiorly, except for a region in the groin and upper third of the thigh, was completely denervated. In addition, the upper two thirds of the left thigh, not operated on, was also completely denervated in a circular fashion.

C. Removal of the Eighth Dorsal Through the Third Lumbar Ganglions.—Studies of skin resistance were done on nineteen extremities after sympathectomy from the eighth or ninth dorsal through the third lumbar ganglion. The patterns obtained are shown in figure 6 and their numerical distribution in table 4. Figure 6 *A* shows the pattern exhibited by five extremities; in these patients the entire lateral half of the body from the eighth or ninth dorsal dermatome to the sole was completely denervated. Two other patients, not illustrated, showed a similar picture, differing only in that an area in the lower region of the abdomen and groin continued to sweat somewhat. Figure 6 *B*, left, shows the pattern observed in six extremities, in which there was complete denervation except for the anterior, medial and lateral surfaces of the thigh, where only partial denervation existed. This picture is exactly similar to that seen most frequently after removal of the eighth dorsal through the second lumbar ganglion. Figure 6 *C*, right, shows the pattern in three extremities; here the anterior region of the thigh showed apparently normal sweating rather than slight sweating as in figure 6 *B*.

TOTAL SYMPATHECTOMY

Patterns of skin resistance were obtained on 10 patients subjected to bilateral near-total sympathectomies from the inferior cervical or second dorsal through the first or third lumbar ganglion. These patients were operated on in four stages, bilateral lumbodorsal splanchnicectomy being carried out at the first hospitalization and bilateral transthoracic sympathectomy being done at the second hospitalization at varying intervals, usually months to years, after the first set of operations. These patients all had hypertension, requiring the second set of operations for various reasons.

Figure 7 exemplifies three of the patterns exhibited by these patients. Figure 7 *A* shows a patient in whom the inferior cervical through the second lumbar ganglion was resected bilaterally. There was complete denervation of the body except for a small band encircling the thorax and the anterior and lateral regions of the thigh. Horner's syndrome was present on the right side in this patient, and the axillas were not denervated. Figure 7 *B* shows a patient in whom the ganglions from the first dorsal through the second lumbar segments were removed bilaterally. The undenervated cutaneous areas were somewhat similar to those in

figure 7 *A*. In addition, however, the ulnar side of the left arm and the dorsum of the left hand were only partly denervated. Again, Horner's syndrome was present on the right, and the axillas were not denervated. Figure 7 *C* is similar except that the band encircling the thorax was wider, and Horner's syndrome was present bilaterally. The right seventh dorsal ganglion was thought to have been spared; this fact probably accounts for the wider thoracic band on the right side. With few exceptions all the patients showed patterns similar to those illustrated.

LUMBAR SYMPATHECTOMY

Studies of skin resistance were done on sixteen extremities in 10 patients subjected to lumbar sympathectomy for the relief of various

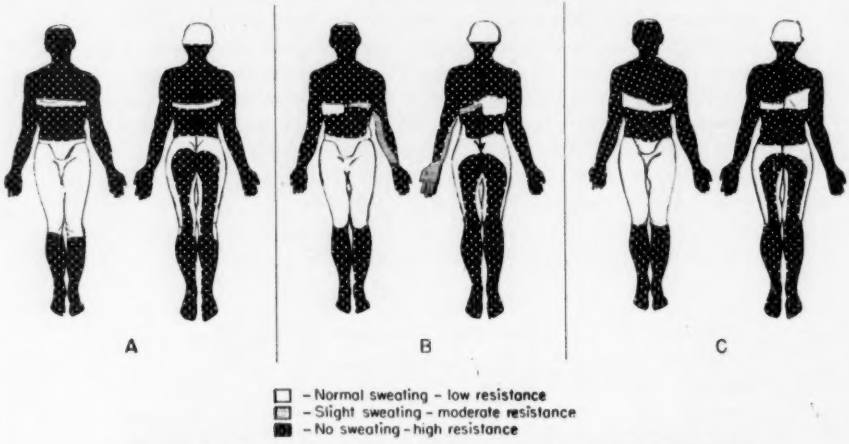

Fig. 7.—Patterns of skin resistance following near-total sympathectomy in four stages. *A*, bilateral excision of inferior cervical ganglions through the second lumbar division. Right Horner's syndrome. Axillas not denervated. *B*, bilateral excision of first dorsal through second lumbar ganglions. Right Horner's syndrome. Axillas not denervated. Note the partial denervation in the eighth cervical and first dorsal distribution on the left arm. *C*, excision of inferior cervical ganglions through the sixth dorsal and of the eighth dorsal through the second lumbar ganglions on the right. Excision of inferior cervical ganglions through the first lumbar division on the left. Bilateral Horner's syndrome. Axillas not denervated. Note the wider band of sweating on the right side of the thorax.

types of peripheral vascular disease. Figure 8 shows the patterns obtained, and table 5 shows the numerical distribution. The following

TABLE 5.—*Numerical Classification of Skin Resistance Patterns Following Lumbar Sympathectomy, as Illustrated in Figure 8*

	A	B	C, Left	D, Left	Others	Total
Number of extremities	5	6	2	1	2	16

combinations of ganlions were removed: first and second lumbar; second and third lumbar; first, second and third lumbar, and third lumbar alone. Two main patterns were observed, as shown in figures 8 *A, B, C,* right, and *D,* right. The pattern shown in *C,* left, is similar to that in *A* and was exhibited by two limbs. The extremity in which only the third lumbar ganglion was removed exhibited the pattern shown in figure 8 *D,*

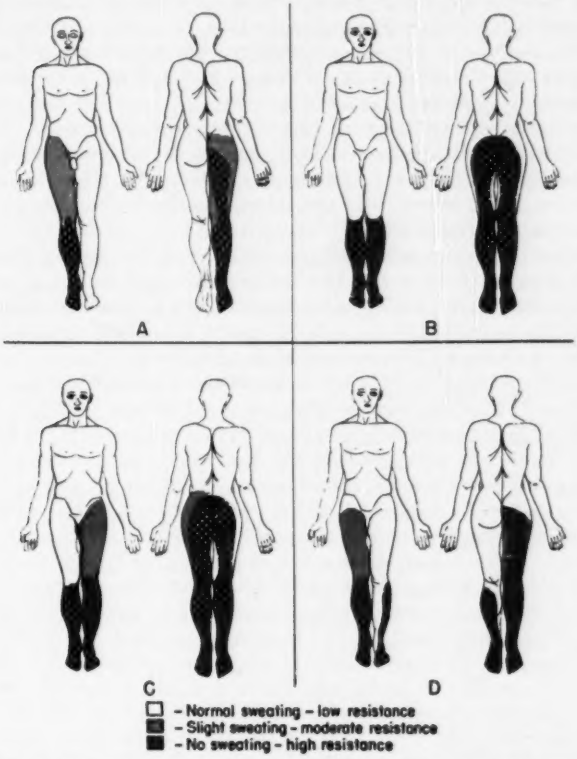

Fig. 8.—Patterns of skin resistance following lumbar sympathectomy. *A,* excision of first and second lumbar ganglions on the right. *B,* excision of second and third ganglions bilaterally. *C,* excision of second and third lumbar ganglions on the right and of first, second and third on the left. *D,* removal of 3 inches (7.62 cm.) of the trunk including probably the second and third ganglions on the right; removal of 2½ inches (6.35 cm.) of trunk with the third lumbar ganglion only on the left.

left. Figure 8 *B* shows the common pattern found when the second and third lumbar ganglions are removed, with complete denervation of the

lower part of the leg and the posterior region of the thigh but with no demonstrable denervation of the anterior region of the thigh. Occasional limbs in which the second and third lumbar ganglions were removed, however, showed partial denervation of the anterior region of the thigh. The pattern shown in figure 8 *C*, left, was exhibited by two limbs in which the first, second and third lumbar ganglions had been resected. This is similar to the pattern in 8 *A* but shows somewhat more extensive denervation on the medial aspect of the thigh. One extremity in which the first, second and third lumbar ganglions were removed showed almost complete denervation of the entire limb. Figure 8 *D*, left, represents the extremity of a patient in whom 2½ inches (6.35 cm.) of sympathetic trunk including only the third lumbar ganglion was removed. There was total denervation of the sole of the foot, dorsum of the foot and lateral half of the extremity to the knee, representing the fifth lumbar and first sacral dermatomes and portions of the fourth lumbar and second sacral dermatomes.

There appears to be considerable variation in the patterns obtained after removal of the eighth dorsal through the first lumbar ganglion, though the majority fall into a few definite groups. The main influence of the first lumbar outflow is on the lower part of the leg and the posterior region of the thigh. That the first lumbar ganglion also has an effect on the anterior region of the thigh is suggested by the findings shown in figure 4 *B*, where the anterior region of the thigh was partially denervated, as contrasted with figure 4 *A*, where it was apparently not denervated at all. In some instances the first lumbar ganglion appears to innervate the entire lower extremity in a diffuse generalized manner, as exemplified by figures 4 *C* and *E*, where ablation of this ganglion caused a moderate increase in skin resistance over the entire extremity. That the ganglion may be the principal source of outflow to the leg in some instances is suggested by figure 4 *F*, where only a relatively small portion of the upper part of the leg remained partly innervated. That it may contribute essentially nothing to the legs is illustrated by figure 4 *D*, where no demonstrable reduction in skin resistance was shown. Here the major outflow to the leg would be presumably through the second and third lumbar ganglions. This picture is similar to that seen following Peet operations and illustrates in addition the insignificance of the lower dorsal outflow to the legs. In exact contradistinction to figure 4 *D* is figure 4 *G*, in which the lower part of the leg and the posterior region of the thigh were denervated but the anterior region of the thigh and the trunk remained almost normally innervated. The outflow from the first lumbar ganglion may be bizarre, as illustrated in figure 4 *H*, the only pattern of its kind we have seen.

After removal of the eighth dorsal through the second lumbar ganglion the anterior region of the thigh continues to sweat either partially or

completely. Such innervation cannot come from above or via nerves of the vertebral canal because of the extensiveness of the upper dissection. It can come only from the third lumbar ganglion, from ganglions below this or via pathways which reach the lumbar nerves without passing first through the usual sympathetic ganglions. That perhaps some portion of the innervation of the thigh comes via the third lumbar ganglion occasionally is suggested by some of the patterns seen after removal of the eighth dorsal through the third lumbar ganglion. This cannot explain the picture entirely, however, because many of the patients who underwent this operation and patients subjected to near-total sympathectomy continue to show sweating of the anterior region of the thigh. We have had no personal experience with resection of ganglions below the third lumbar, but Ray and Console [6] reported continued sweating of the thigh after ganglions below this were resected. Presumably the partial denervation of the lower part of the leg as seen in figure 5 *C* was due to fibers arriving in the area from the third lumbar ganglion, which was still intact in this group of patients. Figure 5 *D* is of interest as it suggests the possibility of the presence of crossed innervation by sympathetic fibers. Anatomically this has been demonstrated, according to Walker.[19] The phenomenon of crossed innervation may account occasionally for some of the most bizarre pictures seen after a presumably routine sympathectomy.

It appears that in a minority of cases the entire half of the body below the eighth dorsal dermatome, including the anterior region of the thigh, can be denervated after sympathectomy of the eighth dorsal through the third lumbar nerve. This leads one to assume that the anterior region of the thigh in some instances receives a portion of its innervation through the third lumbar nerve. In the majority of cases, however, there is not complete denervation, the pattern of skin resistance being exactly the same as that obtained after removal of the eighth dorsal through the first or second lumbar ganglion, and other explanations must be sought. It should be pointed out that anatomic variations, so well known and so frequent in the sympathetic nervous system, may well account for some of the varied pictures obtained.

In the group of near-total sympathectomies no patient had complete denervation of the entire body. Sweating areas remained on the trunk, especially on the anterior region of the thigh. Only 1 patient showed nearly complete denervation. The same problem, therefore, arises here as in the patients discussed previously, namely, the pathway of the sudomotor fibers to the anterior region of the thigh. The patterns following near-total sympathectomy eliminate the possibility of pathways from the upper dorsal regions going to the thigh. A discrepancy would

19. Walker, A. E.: Personal communication to the authors.

appear to arise in that with less extensive sympathectomies, e. g., those including the eighth dorsal through the first lumbar nerve, the anterior portion of the thigh appears to be partly denervated rather than completely undenervated as with the group of total sympathectomies. It is probable that compensatory mechanisms come into play in extensively sympathectomized patients, and although the skin of the anterior region of the thigh is deprived of a part of its sudomotor innervation, the remaining portion when compensating for the absence of other sweating areas on the body is sufficient to give a reading in what is usually called the normal zone of skin resistance. The undenervated areas on the wall of the chest and in the axillas and the variations in Horner's syndrome have all been discussed under the sections on dorsal and thoracic sympathectomies.

Another point of interest is in regard to the question of regeneration. Some of the patients in the near-total sympathectomy group, when seen several years after bilateral lumbodorsal splanchnicectomy, showed areas of sweating on the skin of the medial side of the calf and the lower part of the leg in the region of the saphenous nerve distribution which were not present when they were tested postoperatively. After thoracic sympathectomy these areas on the legs almost invariably disappeared. The cause of this phenomenon is not immediately apparent since the lumbodorsal regions were not reexplored. Were regeneration occurring, one would expect it to occur from the lumbar nerves toward the lumbar skin distribution. A possibility is outflow via the nerves of the vertebral canal,[14] but this presumably was present at the time of the original operation, and these nondenervated areas were not demonstrated at that time. Were they due to an extrasympathetic source of outflow, one would not expect them to disappear after thoracic sympathectomy.

The lower part of the leg and the posterior region of the thigh, representing lower lumbar and sacral dermatomes, are almost always denervated when the upper lumbar ganglions are removed in mainly preganglionic sympathectomies, except when there is removal of the third lumbar ganglion alone. As pointed out, the same can occur when only the first lumbar ganglion is removed. The major portion of the outflow to the lower extremities, therefore, is through the first and second lumbar ganglions, with a variable portion through the third lumbar ganglion. Even with extensive denervation, however, the anterior region of the thigh is rarely completely denervated. When the second and third lumbar ganglions are removed, the thigh appears to sweat in a practically normal fashion in the majority of instances. In some cases in which these were removed, a partial denervation of the thigh occurred, which indicated that the supply to this area is through the second or third lumbar ganglion. That the first lumbar ganglion con-

tributes to the anterior region of the thigh is suggested also by the extremities in which the first, second and third lumbar ganglions were removed, and the undenervated area on the thigh was smaller than when only the second and third were removed, as illustrated by figure 8 *C*, left, and *D*. Little sympathetic sudomotor supply is distributed to the anterior area of the thigh from the lower dorsal ganglions via the trunk connecting the twelfth dorsal to the first lumbar ganglion, as shown by the absence of sweat loss on the thigh after Peet operations. That it does not appear to arise from the higher dorsal ganglions and arrive via bizarre pathways is brought out by the patterns exhibited by patients who underwent extensive thoracic sympathectomies. In the single case in which only the third lumbar ganglion was removed, there was no demonstrable change in the skin resistance of the anterior region of the thigh.

In view of the evidence presented, as well as that given by Ray and Console,[6] it can be concluded that in many cases of thoracolumbar and lumbar sympathectomies undenervated areas, so far as sweating is concerned, continue to be present. Various explanations have been mentioned during the course of this discussion, but the most likely one is that there are pathways present which do not course with the ganglionated sympathetic system in the usual fashion. Cone [15] has noted the absence of the sweating areas on the thigh after lumbodorsal operations in which he has sectioned the anterior roots of the lower dorsal and upper lumbar spinal nerves. Ray and Console [6] have added additional evidence, as they have shown that the continued sweating on the anterior region of the thigh following operation in some cases in which the sympathetic trunk from the inferior cervical to the lowest lumbar ganglions was removed bilaterally could be abolished by the use of spinal anesthesia, resection of anterior roots, procaine hydrochloride block or division of peripheral nerves or by giving tetraethylammonium chloride. They concluded "that the residual pathways to the Th_{12} to L_3 area arise from the corresponding anterior spinal roots. The first lumbar roots seem to play the predominant role but the pathways may arise from roots from Th_{11} to L_2." They speculated on the location of the ganglion cells. The work of Gruss, Wrete and Skoog on the "intermediate ganglia," referred to previously, is of great interest in this regard. Gruss found in fetuses, infants and adults intermediate ganglions limited to the lumbar region. He considered these the remains of a secondary sympathetic trunk which retrogressed normally, the ganglions becoming incorporated into the sympathetic trunk. Wrete also found a concentration of these intermediate ganglions in the lumbar area of embryos and a large but variable number in the lumbar rami of adults. One point of interest is that these ganglions in the cervical region appear more often in or closer

to the spinal nerves than those in the lumbar region, which may account for some of the observed differences between the results of thoracic and lumbar sympathectomies. If such intermediate ganglions are the explanation for the continued sweating on the anterior region of the thigh following sympathectomy, it would appear that they are more closely related to the first lumbar nerve and that their occurrence in this position is more often the rule than not.

It is obvious from data presented that there is a limit to which one can go in judging the extent of a sympathectomy from the postoperative pattern of skin resistance. This holds true for dorsal sympathectomies, in which different patterns occur after the same operation, but is particularly true in lumbodorsal operations and lumbar sympathectomies, in which the same pattern is frequently found after different operations. Thus figures 4 *A*, 5 *B*, left, and 6 *C*, right, all show the same patterns, but one occurred after removal of the eighth dorsal through the first lumbar ganglion, another after removal of the eighth dorsal through the second lumbar ganglion and the third after removal of the eighth dorsal through the third lumbar ganglion. Similarly, figures 4 *B*, 5 *A* and 6 *B*, left, all exhibit the same pattern, but each occurred after a different lumbodorsal sympathectomy. Again, figures 4 *G* and 8 *B* show the same pattern but occurred after removal of the eighth dorsal through the first, second and third lumbar ganglions respectively. The pattern in figure 8 *A* was found after removal of the first and second lumbar ganglions and that on the left of figure 8 *C*, almost the same, was found after removal of the first, second and third lumbar ganglions. Figures 4 *D* and 3 are similar, yet one occurred after removal of the eighth dorsal through the first lumbar ganglion and the other after removal of the ninth through the twelfth dorsal ganglion. One extremity after excision of the eighth dorsal through the first lumbar ganglion and one after excision of the eighth dorsal through the second lumbar ganglion exhibited patterns similar to that of figure 6 *A*, which was seen after sympathectomy of the eighth dorsal through the third lumbar ganglion, the difference being that in the first two there was continued sweating in the groin and the upper medial regions of the thigh but complete denervation otherwise.

SUMMARY AND CONCLUSIONS

1. The patterns of electrical skin resistance of 337 extremities obtained after various types of sympathectomies are presented.

2. After the usual dorsal sympathectomy, removal of the second and third dorsal nerves, the face, arms, hands and upper part of the thorax are usually completely anhidrotic, and Horner's syndrome is not present. Occasionally areas on the face and arms continue to sweat. The axillas frequently are incompletely denervated. The preganglionic sudomotor

outflow to the head and arms is thus usually from below the first dorsal division and the principal outflow to the pupil is usually from above the second dorsal division.

3. Removal of the first dorsal ganglion usually results in Horner's syndrome, but occasional patients fail to exhibit it after excision of this nerve. The outflow to the pupil can therefore arise from above the first dorsal ganglion in rare cases.

4. Scattered areas on the wall of the chest and the axilla continue to sweat after extensive thoracic or near-total sympathectomy.

5. The lower dorsal ganglions contribute an insignificant sudomotor outflow to the lower extremities.

6. The first and second lumbar ganglions contribute the major preganglionic sudomotor outflow to the lower extremities. The third lumbar ganglion contributes a variable amount.

7. The anterior region of the thigh receives innervation from the first lumbar ganglion mainly but also from the second lumbar ganglion at times and perhaps from the third.

8. The lower part of the leg, the foot and the posterior region of the thigh are almost completely anhidrotic when the upper lumbar ganglions, in whatever combination, are resected. Removal of the third lumbar ganglion alone gives a segmental postganglionic pattern.

9. The entire lower extremity is occasionally completely denervated after removal of the eighth dorsal through the third lumbar ganglion, but in the majority of cases the anterior part of the thigh continues to sweat even after near-total sympathectomy. It has been shown by others that this area can be rendered anhidrotic by section of the anterior roots of the lumbar nerves, especially the first.

10. Sympathetic pathways lying entirely outside the ganglionated sympathetic trunks probably account for the areas of residual sweating after the conventional sympathectomies.

11. The intermediate ganglions of Hirt, Wrete and Skoog may be the extrasympathetic pathways in the cervical, thoracic and lumbar regions.

12. One cannot always tell with exactitude the extent of sympathectomy performed from the postoperative pattern of skin resistance because of the diffuse outflow and the similarity of pattern following different combinations of ganglionectomy, particularly in the lower extremities.

INFLUENCE OF THE AUTONOMIC NERVOUS SYSTEM ON THE CEREBRAL BLOOD SUPPLY

A. de SOUSA PEREIRA, M.D.

Professor of Surgery, Oporto University, Faculty of Medicine

OPORTO, PORTUGAL

CLINICAL and experimental research, developed recently, showed that the autonomic nervous system may influence the disturbance of the arterial circulation of the brain in cases of arterial thrombosis and ischemia.[1] During investigations I have observed, in cases of cerebral embolism or thrombosis, clinical improvement following the physiologic interruption by blocking with an anesthetic or the surgical section of the sympathetic innervation of the arteries of the brain. This observation led me to investigate the changes caused by these operations in the brain circulation.

I studied some patients with neurologic disturbances due to disorders of the arterial circulation of the brain. The study of the cerebral circulation was done by injecting 12 cc. of thorotrast® (colloidal thorium dioxide) into the primitive carotid artery. Then the classic roentgenograms of the three phases (arterial, arteriovenous and venous) of the brain circulation were obtained. After this arteriographic study, I carried out on these patients repeated blockings of the middle cervical and stellate ganglions by means of descending infiltration anesthesia.[2] In the cases in which a favorable result concerning the neurologic symptoms was obtained, the surgical interruption of the cerebral vasomotor innervation was performed. Then bilateral cervical sympathectomy was performed, completed by periarterial sympathectomy of the carotid and vertebral arteries.

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2. De Sousa Pereira, A.: Blocking of the Middle Cervical and Stellate Ganglions with Descending Infiltration Anesthesia: Technic, Accidents and Therapeutic Indications, Arch. Surg. **50**:152-165 (March) 1945.

To evaluate the influence of the interruption of the vasomotor innervation of the cerebral arteries on the arterial circulation of the brain, I studied 6 patients before and after the operation. The arteriographic study of these patients was performed during a period varying from ten days to five months after the operation. The quantity of thorotrast[9] injected and the roentgenologic technic employed were the same; hence a correct interpretation of the results obtained in each case was permitted.

The first 3 patients in this series suffered from hemiplegia on the right side and aphasia. According to the arteriographic study, neurologic disturbances were caused in the first patient (24 years old) by complete thrombosis of the left internal carotid artery and in the other 2 patients (47 years and 44 years old) by partial thrombosis of this artery. The partial thrombosis of the left internal carotid artery of the second patient had been due to cerebral embolism on the left side.

In the fourth patient (42 years old) hemiplegia developed on the left side after traumatic injury of the head. The arteriographic study showed partial thrombosis of the right internal carotid artery.

The fifth patient (48 years old) presented progressive hemiparesis and hemiatrophy of the upper and lower limbs on the left side. This condition had progressed slowly during a period of five years. The arteriographic study of the right carotid artery showed arterial ischemia of the frontal lobe and of the anterior part of the parietal lobe of the right side.

The sixth patient (25 years old) remained in coma during five days after a deep craniocerebral wound caused by a bullet that went through the right temporal region and came out at the upper left parietal region, and when he came out of this condition he presented hemiplegia on the left side. Since the hemiplegia persisted, I made the arteriographic study of the right internal carotid artery a month and a half later. It showed a pronounced diminution in the caliber of the cerebral arterial branches located near the wound in the brain. In a comparison of the arteries in this area with the arteries in other normal cerebral areas one was struck by a condition of pronounced spasm noticeable at the level of the wound.

Every one of these patients, besides the disturbances of motility of the limbs, presented also psychic disturbances particularly characterized by a depression of the mental activity and a state of marked emotional reaction. From the beginning of the vascular disturbances of the brain these patients changed in character. They were no longer interested in intellectual activity. They suffered from excessive emotional reactions and wept at the least provocation.

The arteriographic study of the first patient in this series showed thrombosis of the left internal carotid artery. The arteriographic study of the vertebral artery on the same side showed circulation in the pos-

terior fossa and no circulation in the area of distribution of the branches of the left internal carotid artery. From this study I came to the conclusion that the arterial circulation of the left cerebral hemisphere came principally from the right carotid artery.

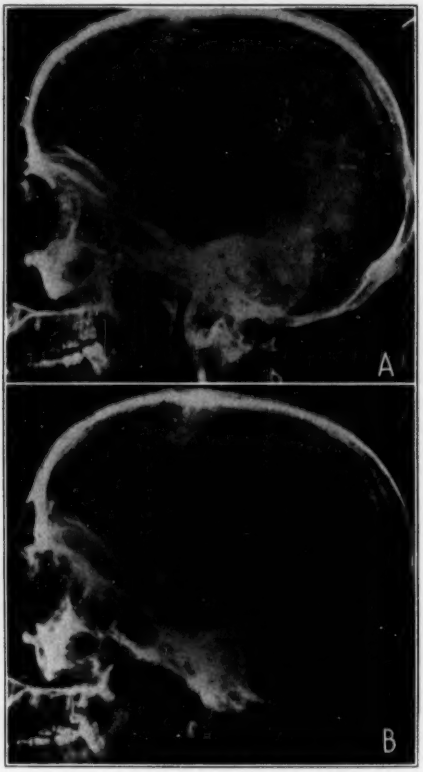


Fig. 1 (case 1).—Thrombosis of the left internal carotid artery following cerebral embolism. *A*, arteriogram of the right carotid artery. *B*, arteriogram of the right carotid artery three and a half months after cevical sympathectomy on the left side and one month after cervical sympathectomy on the right.

In order to improve the cerebral circulation in this patient I performed bilateral cervical sympathectomy. The arteriographic study of the right carotid artery was then repeated three and a half months after the operation on the left side and one month after the operation on the right side. A comparison of the studies, made before and after

the operation showed a greater development of the arterial circulation of the brain following the operation (fig. 1).

The second patient had been suffering from aphasia and hemiplegia of the right side for seven years after cerebral embolism on the left side.

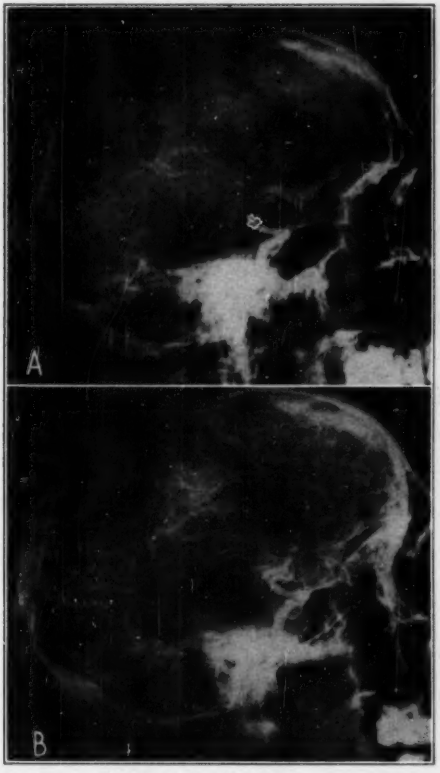


Fig. 2 (case 2).—Partial thrombosis of the left internal carotid artery following cerebral embolism. *A*, arteriogram of the left carotid artery. *B*, arteriogram twenty-one days after cervical sympathectomy on the left side and twelve days after cervical sympathectomy on the right.

The arteriographic study showed partial thrombosis of the internal carotid artery on the left side and diminished arterial circulation of the left hemisphere. Twenty-one days after cervical sympathectomy on the left side and twelve days after the cervical sympathectomy on the right

side I repeated the arteriographic study of the left carotid artery. This showed an improvement in the arterial circulation in the left hemisphere (fig. 2).

In the third patient, suffering from aphasia and hemiplegia affecting the right side, I repeated the arteriographic study of the left carotid

Fig. 3 (case 3).—Partial thrombosis of the left internal carotid artery. *A*, arteriogram of the left carotid artery. *B*, arteriogram ten days after bilateral inferior cervical sympathectomy.

artery ten days after bilateral inferior cervical sympathectomy. This study showed increased arterial circulation, particularly at the level of the left frontal lobe. Branches of the anterior cerebral artery that are not evident on the arteriogram made before the operation can be seen on the postoperative arteriogram (fig. 3).

A favorable development of the arterial circulation of the brain was also observed after cervical sympathectomy on the fourth patient, suffering from hemiplegia of the left side caused by injury of the head. Twenty-six days after the bilateral inferior cervical sympathectomy the

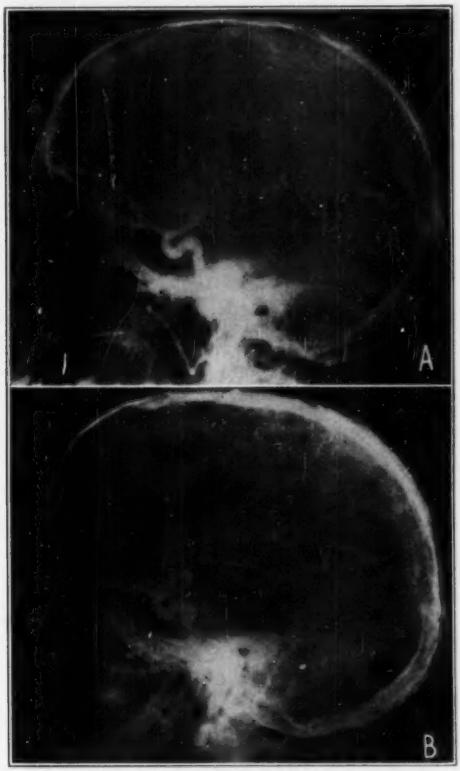


Fig. 4 (case 4).—Partial thrombosis of the right internal carotid artery. *A*, arteriogram of the right carotid artery. *B*, arteriogram twenty-six days after bilateral inferior cervical sympathectomy.

arteriographic study of the right carotid artery showed increased arterial circulation in the right hemisphere (fig. 4).

The arteriographic study made a fortnight after bilateral inferior cervical sympathectomy and periarterial sympathectomy of the carotid and vertebral arteries in the fifth patient, suffering from progressive

hemiparesis and hemiatrophy on the left side for five years, showed evident improvement in the arterial circulation in the right cerebral hemisphere (fig. 5).

Most interesting was the study of the sixth patient, suffering from hemiplegia affecting the left side which developed after a bullet wound

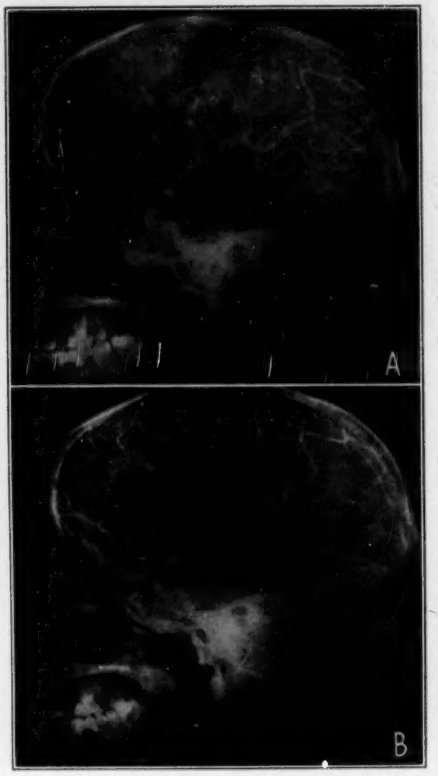


Fig. 5 (case 5).—Cerebral ischemia on the right side and occlusion of the anterior cerebral artery. *A*, arteriogram of the right carotid artery. *B*, arteriogram made a fortnight after bilateral inferior cervical sympathectomy.

in the brain. The arteriographic study of the right carotid artery made a month and a half after the injury showed the presence of spasm on the arterial branches located near the wound. A second arteriogram of the right carotid artery was made five months after bilateral inferior cervical sympathectomy and bilateral periarterial sympathectomy of the

carotid and vertebral arteries. This one showed that arterial spasm of the arteries located near the wound of the brain had disappeared. An evident increase in arterial circulation at the level of the right cerebral hemisphere could also be noticed (fig. 6).

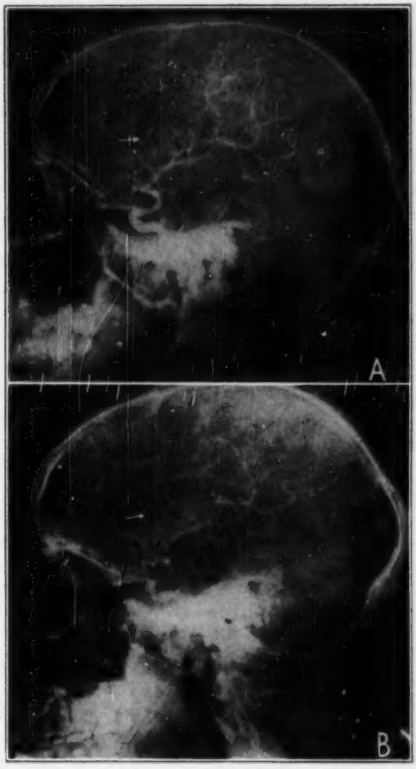


Fig. 6 (case 6).—Spasm of the cerebral arterial branches located near a brain wound caused by a bullet that went through the right temporal region. *A*, arteriogram of the right carotid artery made a month and a half after wounding. *B*, arteriogram five months after bilateral inferior cervical sympathectomy and bilateral periarterial sympathectomy of the carotid and vertebral arteries.

From a clinical point of view, every one of these patients recovered, to a certain extent, the control of his limbs. However, this improvement varied. In the third it was slight, but it was remarkable in the other patients, particularly the sixth one. This patient recovered almost

completely, except for a slight functional deficiency in the extensor muscles of the left leg. In regard to aphasia, the second patient improved slightly, while the third patient recovered remarkably. Before the operation the latter pronounced only a few words, but one month after the operation he talked and expressed his ideas with more ease.

Another important fact observed in these cases was that of the psychic changes which followed the operation. The patients became more interested in current affairs concerning their private life. They showed increase in self confidence, their preoperative depressed condition improved and their emotional reactions became nearly normal. These observations suggest that the neurologic and psychic improvement was probably brought about by the increased blood supply to the brain caused by the development of cerebral arterial circulation after cervical sympathectomy.

SUMMARY

The clinical and arteriographic study of patients suffering from disturbances of the arterial circulation of the brain due to thrombosis and ischemia showed that the surgical interruption of the vasomotor innervation of the carotid and vertebral arteries is followed by increased cerebral arterial blood supply. Improvement in the brain circulation was followed by favorable neurologic and psychic changes.

The sixth case of this series showed that a wound in the brain may be followed by spasm of the cerebral arterial branches located near the injury. The spasm was evident a month and a half after a bullet wound in the brain. The arteriographic study performed five months after the surgical interruption of the vasomotor innervation of the carotid and vertebral arteries showed that the spasm had disappeared and that the cerebral arterial circulation had improved.

BILATERAL BRONCHIECTASIS

An Analysis of Forty-Three Consecutive Cases

G. E. LINDSKOG, M.D.
AND
R. D. ALLEY, M.D.*
NEW HAVEN, CONN.

BRONCHIECTASIS is a bilateral disease in approximately 30 per cent of patients afflicted with this disorder. During the past decade and a half, the indications for pulmonary resection, originally restricted to the cases of unilobar or unilateral involvement, have been extended to include suitable cases of bilateral disease.[1] Resection remains the only known method for permanent and total cure of bronchiectasis. Patients with bilateral disease, who for one reason or another are not candidates for surgery, experience the unfavorable clinical course of untreated or medically treated disease so familiar to all. In our hands, at least, the over-all surgical rehabilitation of the patients with bilateral disease has fallen far short of the brilliant results obtained in the group with unilateral bronchiectasis because when the disease is bilateral the

From the Department of Surgery, Yale University School of Medicine.

* Fellow in Thoracic Surgery under a contract with the Office of Naval Research as Project N6ori-44 Task Order XI.

1. (*a*) Eloesser, L.: Bilateral Lobectomy, Surg., Gynec. & Obst. **57**:247-249, 1933. (*b*) Lewis, I.: Bilateral Lobectomy for Bronchiectasis, Brit. J. Surg. **24**:362-367, 1936. (*c*) Overholt, R. H.: Bilateral Trilobectomy: Report of Successful Case, J. A. M. A. **109**:127-128 (July 10) 1937. (*d*) Ross, D. E.: Bilateral Lobectomy (Presentation of Two Cases), Canad. M. A. J. **39**:549-552, 1938. (*e*) Ingraham, R.: Case of Situs Inversus with Extensive Bilateral Bronchiectasis Dating from Early Childhood and with Bilateral Lobectomies, M. Women's J. **46**:593-598, 1939. (*f*) Churchill, E. D.: Resection of Lung, Surgery **8**:961-991, 1940. (*g*) Blades, B., and Graham, E. A.: Surgical Treatment (Lobectomy) of Bilateral Bronchiectasis, Surg., Gynec. & Obst. **75**:457-464, 1942. (*h*) Bradshaw, H. H., and O'Neil, J. F.: Surgical Treatment of Bronchiectasis, Surg., Gynec. & Obst. **77**:315-318, 1943. (*i*) Pilcher, R.: Segmental Resection of Lung for Bronchiectasis, Lancet **1**:843-846, 1946. (*j*) Bisgard, J. D., and Swenson, S. A.: Bilateral Lobectomy for Bilateral Bronchiectasis, Arch. Surg. **54**:483-490 (May) 1947. (*k*) Overholt, R. H.; Woods, F. M., and Betts, R. H.: An Improved Method of Resection of Pulmonary Segments, J. Thoracic Surg. **17**:464-479, 1948. (*l*) Graham, E. A.: With How Little Lung Tissue is Life Compatible? Report of Patient from Whom All Pulmonary Tissue Except Two Upper Lobes Was Successfully Removed, Surgery **8**:239-246, 1940. (*m*) Kay, E. B.; Meade, R. H., Jr., and Hughes, F. A.: Surgical Treatment of Bronchiectasis, Ann. Int. Med. **26**:1-12, 1947.

involvement all too frequently is so extensive as not to permit complete extirpation of all diseased parenchyma. In the bilateral group one must compromise not infrequently by excising only the most extensively affected components, hoping thus to improve the lot of the patient by changing the distressing symptoms in degree.

Whereas bilateral pulmonary resection in the treatment of bilateral bronchiectasis has become accepted surgical practice, there have hitherto been few published reports in which the operative material is analyzed in the light of the original total case material from which it was derived to appraise the over-all salvage from a series of unselected cases. The most brilliant operative results in individual cases of bilateral bronchiectasis have been seen in the younger age group. Graham [11] removed all but the upper lobes in a boy of 14 years of age. Pilcher [11] subjected all five lobes to segmental or total resection in a 12 year old girl, conserving only the apical and subapical segments of the upper lobes and the dorsal segments of the lower lobes. These feats were carried out in young patients. Although the reduction in cardiac and respiratory reserve which accompanies advancing age and long-standing chronic respiratory infection tends to limit the extent of surgical procedures which may be undertaken and the proportion of candidates which may be selected from the older age groups, with improvements in surgical management increasing numbers of older patients are being operated on.

What is the over-all salvage from a consecutive series of cases with bilateral bronchiectasis representing a random sampling of all age groups? The cases here reviewed are presented as a partial answer to this question. Forty-three cases of bilateral suppurative bronchiectasis all proved by bronchography were observed at the thoracic surgical service of the New Haven Hospital during the nine year period Jan. 1, 1939 to Jan. 1, 1948. The case material drawn largely from the state of Connecticut by this 550 bed general hospital represents cases referred by clinics (25 per cent) or the local physicians (75 per cent). Our experience with these cases, therefore, perhaps represents a sampling of the general experience with bilateral bronchiectasis.

A comparative review of the cases coincidentally reflects advances in surgical management which have been made in the past decade. This period witnessed the transition from the technic of mass ligation to that of individual ligation in the handling of the hilus, the discovery and general use of penicillin, the development of blood banks, which made adequate blood for transfusions readily available, and important advances in anesthetic technic. These factors have played a significant role in the reduction of postoperative morbidity. It will be seen that the last lobectomy by the technic of mass ligation in this clinic was performed in 1943, although the dissection technic was employed in 1942.

This period has also witnessed a transition from the use of static measurements of the various components of pulmonary volume to the

evaluation of dynamic pulmonary function including comparison of resting or standard exercise ventilatory requirement with maximum ventilatory capacity in the evaluation of candidates for resection. Although still crude, the dynamic tests of pulmonary function are helpful not only in the preliminary selection of candidates for surgery but in the reevaluation of cases before contralateral operation is carried out, particularly in patients who have experienced bronchopleural fistula and empyema with attendant impairment of pulmonary function after the first operation.

CASE MATERIAL

The 43 patients with bilateral bronchiectasis ranged in age from 9 to 66 years, with an average of 30.4 years. Of these, 13 were females and 30 were males. A total of 164 lobes were demonstrably involved,

TABLE 1.—*Lobar Involvement in 43 Cases of Bilateral Bronchiectasis*

Number of Cases	Right Lung			Left Lung		
	Upper Lobe	Middle Lobe	Lower Lobe	Upper Lobe	Lingula	Lower Lobe
6	+	+	+	+	+	+
3	+	+	+	..	+	+
3	+	+	+	..	..	+
1	+	+	..	..	+	+
1	+	..	+	+	..	..
1	..	+	+	+	..	+
11	..	+	+	..	+	+
3	..	+	+	..	..	+
4	..	+	..	..	+	+
3	..	..	+	..	+	+
5	..	..	+	..	..	+
Total 43	14	34	38	8	23	42

of which 86 were on the right and 78 were on the left. Table 1 depicts the distribution and incidence of involvement of the various lobes. All five lobes and the lingula were involved in 6 patients. The combined involvement of the lower with the middle lobe of the right lung was observed in 29 cases and of the lower lobe of the left lung with the lingula in 28 cases. Involvement of the lower lobe of the right lung and not of the middle lobe was observed in 9 cases and involvement of the lower lobe of the left lung and not of the lingula in 14 cases.

Of the 43 patients with bilateral disease, 26 were selected after appropriate study as suitable candidates for operation. Of these, 5 refused surgical treatment and 1 is still awaiting it. Twenty patients have received surgical treatment involving the removal of a total of 49 lobes in 33 operations. (For convenience, the lingula is referred to as a lobe in all tabulations.) In 12 of the 20, bilateral resection has been completed (table 2), and 8 have undergone unilateral resection (table 3).

Of the 12 who have undergone bilateral operations, 9 will not be subjected to further surgical procedures. In 6 of these 9 "total" removal of the diseased area has been carried out. One has minimal involvement of the remaining upper and lower lobes of the right lung and a

TABLE 2.—*Data on 12 Cases of Bilateral Resection for Bronchiectasis*

No.	Patient	Age	Lobes of Right Lung			Lobes of Left Lung			Type of Resection	Operative Date	Postoperative Status
			Upper	Middle	Lower	Upper	Lingula	Lower			
1*	G. R.	16	..	×	×	..	..	..	Subtotal	1937	Much improved; minimal cough and sputum, occasional hemoptysis
			..	..	..	..	+	×	Subtotal	1939	
2*	M. N.	20	..	..	..	..	+	×	Subtotal	1940	Improved; moderate cough, 1 ounce sputum per day
			..	×	×	..	..	..	Subtotal	1941	
3	J. R.	15	..	..	×	..	..	..	Subtotal	1940	Much improved; minimal cough and sputum
			..	..	..	..	×	×	Subtotal	1941	
			..	×	⊕	..	..	..	Total	1948	
4	W. B.	9	..	×	..	..	..	..	Total	1942	Much improved; minimal cough and sputum
			..	..	..	..	×	×	Total	1943	
5	J. S.	16	..	..	..	..	..	×	Total	1942	Much improved; minimal cough and sputum
			..	..	×	..	..	..	Total	1944	
6	H. G.	30	+	×	+	..	..	..	Subtotal	1942	Improved; moderate cough; 2 ounces sputum per day
			..	..	..	..	×	×	Total	1944	
7*	L. B.	28	..	×	×	..	..	..	Subtotal	1943	Improved; moderate cough; 2 ounces sputum per day
			..	..	..	..	+	×	Total	1945	
8	C. N.	21	..	..	..	..	×	×	Total	1944	Asymptomatic
			..	×	..	..	..	..	Total	1946	
9	E. K.	13	..	..	..	..	×	×	Total	1947	Much improved; minimal cough; no sputum
			..	×	..	..	..	..	Total	1947	
10	G. R.	36	..	..	..	..	×	×	Total	1947	Much improved; minimal cough; no sputum
			..	×	..	..	..	..	Total	1948	
11	F. C.	27	..	..	..	..	×	×	Total	1947	Much improved; minimal cough and sputum
			..	×	+†	..	..	..	Total	1948	
12	E. R.	26	..	..	..	..	..	×	Total	1947	Asymptomatic
			..	×	×	..	..	..	Total	1948	

* These patients may require further surgical treatment.
† Only the posterior basilar segment was involved in this case.
\+ indicates diseased lobe remaining, × lobe resected and ⊕ secondary resection of subtotal stump.

TABLE 3.—*Data on 8 Cases of Bilateral Bronchiectasis with Unilateral Resection*

No.	Patient	Age	Lobes of Right Lung			Lobes of Left Lung			Type of Resection	Operative Date	Postoperative Status
			Upper	Middle	Lower	Upper	Lingula	Lower			
1	P. M.	23	..	..	+	..	+	×	Total	1942	Improved
2*	W. C.	49	+	×	..	..	+	+	Subtotal	1943	Improved
3	D. M.	25	..	+	+	..	×	×	Total	1945	No change
4	E. R.	26	..	+	+	..	×	×	Total	1946	Improved
5	S. S.	12	..	+	+	..	×	×	Total	1947	Improved
6*	Y. S.	10	+	×	×	+	+	+	Total	1947	Improved
7	E. M.	47	..	..	+	..	..	×	Total	1947	Improved
8*	J. M.	49	+	×	×	..	..	+	Total	1947	Improved

* These patients were not considered candidates for further surgical treatment.
\+ indicates diseased lobe remaining and × lobe resected.

middle lobe stump remaining after a subtotal resection; another has a single right basilar segment involved, and the third has a small bronchiectatic left lower lobe and a lingular stump remaining. Three of the 12 patients who have undergone bilateral resection may require

further surgical treatment, since they have residual lingular involvement which was missed on bronchographic examination preceding resection of the lower lobe of the left lung and one or two subtotal bronchiectatic stumps.

Of the 8 patients who have undergone unilateral operations, 7 have been subjected to total resection and 1 to a subtotal resection. No further surgical intervention is contemplated for 3 patients of this group because of the extensive nature of their disease, and the other 5 are awaiting operation.

Operation was not advised in 17 of the 43 cases for the following reasons: Five had extensive involvement of all lobes, and of these 1 had cor pulmonale with chronic heart failure; in 5 others the disease was also considered to be too extensive, and of these 2 were elderly patients; 4 had marked emphysema; 1 had rheumatic heart disease; 1 had borderline respiratory reserve, and 1 had minimal symptoms.

One patient with involvement of all five lobes had situs inversus. Another patient (S. S., table 3) had a Klippel-Feil deformity and was born with polydactyly. The association of Klippel-Feil deformity and congenital bronchiectasis has been previously reported.[2] In 1 of the patients who was refused surgical treatment because his disease was too extensive, a brain abscess subsequently developed, from which he recovered after surgical drainage.

As previously stated, the average age of this series of patients was 30.4 years, with a range of 9 to 66 years. The 20 patients who were operated on ranged in age from 9 to 49 years, there being 2 at 49 years, with an average age for the operative group of 26 years. The 16 patients who were not considered suitable candidates for surgical operation ranged in age from 18 to 66 years, with an average of 36.6 years. Although 2 patients as old as 49 years of age were surgically treated and 1 of 62 years of age was offered operative treatment but refused it, the patients for whom surgical intervention was not considered were on an average a decade older than those who came to surgical resection.

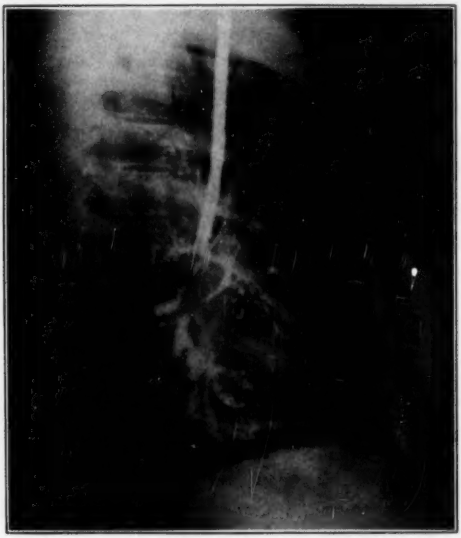
OPERATIVE TECHNIC, MORBIDITY AND MORTALITY

Of the 33 resections (49 lobes removed), 24 (36 lobes removed) were total resections done by the technic of individual ligation, and 9 (13 lobes removed) were subtotal resections done by mass ligation. The transition from subtotal to total resection occurred gradually during 1942 and 1943. In 1 case (patient J. R., table 2) a residual bronchiectatic stump present after previous subtotal resection of the lower lobe

2. Alix y Alix, J.: Congenital Bronchiectasis with Klippel-Feil Syndrome, Rev. clin. españ. **1**:435-437 (Nov. 1) 1940.

of the right lung was subsequently excised together with the middle lobe, the technic of individual ligation being employed. The bronchogram showing the residual stump of the lower lobe and the diseased middle lobe is illustrated in the accompanying figure.

Before penicillin was generally available, the patients received a sulfonamide by mouth during the preoperative and postoperative period and 3 to 5 Gm. of sulfanilamide was placed in the pleural cavity before closure of the operative wound. After the availability of penicillin for civilian use, this drug was given preoperatively and postoperatively,



Bronchogram of J. R. (table 2) showing residual bronchiectatic stump of lower lobe of right lung following subtotal lobectomy and diseased middle lobe. The stump and the middle lobe of the right lung are characteristically rotated posteriorly.

and 100,000 units were left in the pleural cavity at the end of operation. Seventeen of the 33 patients who underwent resection were protected in this manner by penicillin, and of these, 3 received both penicillin and sulfonamide.

The average postoperative period in the hospital for patients who underwent subtotal resection was 68 days, with a range of 19 to 147 days. The average postoperative period for patients who underwent total resection was 25.5 days, with a range of 12 to 100 days.

Of the 9 patients who underwent subtotal resection, bronchopleural fistula developed in 6; empyema in 7 (of whom 1 required drainage followed by Schede thoracoplasty), atelectasis in 4, pneumonitis in 3 and an intrapleural hemorrhage in 1, for which the chest was reopened but no specific bleeding point was found. Three of the 24 total resections were complicated by the development of bronchopleural fistula with associated empyema (2 patients requiring surgical drainage, which was followed by Schede thoracoplasty in 1), 14 by atelectasis, 4 by pneumonitis and 1 by a postoperative intrapleural hemorrhage which was not of sufficient degree to necessitate reopening of the wound. In none of the 17 patients who received penicillin parenterally did a recognizable bronchopleural fistula develop. There were no operative, hospital or late deaths in either group (table 4).

TABLE 4.—*Morbidity and Mortality in 20 Cases of Bilateral Bronchiectasis*

Type of Resection	Number	Empyema	Broncho-pleural Fistula	Atelectasis	Pneu-monia	Post-operative Hemor-rhage	Death
Subtotal.....	9	7	6	4	3	1	0
Total.....	24	3	3	14	4	1	0

RESULTS

Of the 12 patients who have undergone bilateral operations, 2 are entirely without symptoms and 6 have a slight cough with little or no sputum. The 6 patients in whom complete extirpation of the disease by means of total lobectomy was carried out fall into this group. The patient with residual disease of the upper and lower lobes of the right lung and contralateral subtotal stump, although markedly improved, still produces 2 ounces (60 cc.) of sputum each day. The 3 patients who have residual bronchiectatic stumps and lingular involvement are all markedly improved but have a moderate cough productive of up to 2 ounces (60 cc.) of sputum each day. It is our impression that the residual stumps following subtotal resection are a significant factor in the continuing, although reduced, symptoms in these cases.

Of the 8 patients who have undergone unilateral operations, 7 are improved and 1 is no better; none is free of symptoms.

SUMMARY

A series of 43 consecutive cases of bilateral bronchiectasis representing all age groups is presented and analyzed. Twenty-six patients were selected for surgical treatment, of whom 20 accepted treatment, 5

refused it and 1 is awaiting operation. Sixteen patients were regarded as unfit for surgical treatment, and 1 had insufficient symptoms to warrant it. Twelve of the 20 surgical patients have undergone bilateral operations. Of these, 8 have negligible or no symptoms and 4 have minimal or moderate symptoms. In only 6 of the entire group has total excision of all the diseased area by the technic of individual ligation been performed. Of the 8 patients who have undergone unilateral resection, all but 1 is improved. Five of these 8 are under consideration for contralateral surgical procedures. Although the age of patients accepted for surgical treatment was on the average 10 years less than that of those who were not regarded as candidates for operation, those to whom it was offered ranged in age from 9 to 62 years and 2 patients 49 years old were surgically treated.

Details of operative morbidity are discussed. There were no deaths in this series of 33 resections in 20 patients with bilateral bronchiectasis.

PATHOGENESIS OF ACUTE HEMORRHAGIC PANCREATITIS

JOSEPH GASTER, M.D.
Instructor in Surgery, College of Medical Evangelists
LOS ANGELES
ALEXANDER BLAIN III, M.D.
AND
KENNETH N. CAMPBELL, M.D.
DETROIT

THE EXACT mechanism in the production of acute hemorrhagic pancreatitis is unknown. Although acute pancreatitis was first produced experimentally in 1855,[1] we are today still uncertain of the relative importance of the various factors involved in the pathogenesis of inflammatory and necrotizing lesions of the pancreas.

That this subject is of direct practical importance to the surgeon will be illustrated in cases to be described.

The problem as encountered at the Alexander Blain Hospital is such that during the past five years an average of only 1 patient a year has been treated, with a mortality rate of 40 per cent. The 2 deaths occurred in patients with hemorrhagic pancreatitis. One death occurred five years after cholecystectomy and choledochotomy for stones in the common duct. At autopsy the main pancreatic duct was found to be occluded by a stone impacted in the ampulla of Vater. All the 3 surviving patients had also undergone previous operations on the biliary tract.

The purpose of this communication is to evaluate the present state of our knowledge concerning the causes of pancreatitis, with particular reference to hemorrhagic pancreatitis, and to illustrate from our own small series some of the questions which remain unsettled.

The following classification modified from that of R. Jones Jr. lists the various factors which have been considered to cause acute pancreatitis.

From the Department of Surgery, Alexander Blain Hospital and Clinic, Detroit.

1. Bernard, C.: Leçons de physiologie expérimentale appliquée à la médecine, Paris, J. B. Bailliere, 1856, vol. 2, p. 278.

CLASSIFICATION OF ETIOLOGIC FACTORS IN ACUTE PANCREATITIS

I. Pancreatitis of infectious origin
   - A. Lymphogenous
   - B. Hematogenous
   - C. Extension via pancreatic ducts from duodenum or bile ducts
   - D. Direct extension from infective foci or diseased adjacent viscera
   - E. Activation of enzymes by bacteria in normal gland

II. Pancreatitis of noninfectious origin
   - A. Due to reflux into pancreatic duct of
     1. Bile ("common channel" theory), incident to
        - (*a*) stone or edema of ampulla of Vater
        - (*b*) spasm of sphincter of Oddi
        - (*c*) miscellaneous factors
     2. Duodenal contents
   - B. Obstruction of pancreatic ducts by
     1. Epithelial metaplasia (Rich and Duff)
     2. Stone in pancreatic duct or ampulla of Vater
     3. Tumor, stricture or edema
     4. Duodenal diverticulum (Ogilvie)
   - C. Trauma
   - D. Vascular accidents:
     Embolus, thromobosis, rupture

III. A combination of two or more factors

I. *Infectious Origin.*—Bacteriologic studies show that the early lesions in many cases are sterile and that the presence of bacteria is incidental,[1a] terminal or due to postmortem changes. Pólya [2] has shown that the histopathologic picture of pancreatitis is that of hemorrhage and necrosis with the absence of every sign of inflammation. Nordmann [3] also emphasized that scarcely a single leukocyte could be found in the interior of the necrotic areas. Leukocytes are found at the periphery

1a. Tower, L. E.: Pathologic Physiology of Experimental Gangrenous Pancreatitis, J. A. M. A. **80**:1112 (April 10) 1926.

2. Pólya, E. A.: (*a*) Zur Pathogenese der acuten Pankreasblutung und Pankreasnekrose, Klin. Wchnschr. **43**:1562, 1906; (*b*) Ueber die Pathogenese der akuten Pankreaserkrankungen, Mitt. a. d. Grenzgeb. der Med. u. Chir. **24**:1, 1912.

3. Nordmann, O.: Experimente und klinische Betrachtungen über die Zusammenhänge zwischen acuter Pankreatitis und Erkrankungen der Gallenblase, Arch. f. klin. Chir. **102**:66, 1913.

of the lesion only secondarily as a reaction of the surrounding living tissue. Ravdin and Johnston [4] have pointed out the fallacies in the theory of infectious origin of acute pancreatitis.

The variable and inconstant results of experimental and clinical bacteriologic studies indicate that infection is rarely a cardinal factor in causation of acute pancreatitis but is rather a secondary factor, actively preying on already injured pancreatic tissue.

II. *Noninfectious Origin.*—A. Reflux of Bile into the Pancreatic Duct: "Common Channel" Theory: This theory originated when Opie [5] in 1901 discovered at autopsy an impacted stone at the ampulla of Vater. He was able to force bile into the pancreatic duct by applying pressure to the gallbladder.

There are two important prerequisites that must be fulfilled before Opie's theory of a common channel can be accepted. The first is that there must be the anatomic possibility of the formation of a common channel in a reasonable percentage of persons. The two ducts must unite to form a common ampulla before emptying into the duodenum, and the union must occur at a sufficient distance from the duodenal orifice to allow for obstruction of the orifice without obstructing either of the ducts.

The mode of junction of the two ducts has been studied several times.[6] Rienhoff and Pickrell [7] concluded that a common channel could be produced in 17 per cent of the patients. Jones [8] found the ducts joined above a common sphincter in an average of 61 per cent of the cases, thus permitting reflux of bile. Cholangiography has also demonstrated that a common channel exists [9] in 10 to 20 per cent of cases.

4. Ravdin, I., and Johnston, C. G.: The Etiology and Pathogenesis of Acute Hemorrhagic Pancreatitis, Am. J. M. Sc. **205**:277 (Feb.) 1943.

5. Opie, E. L.: Relation of Cholelithiasis to Diseases of Pancreas and to Fat Necrosis, Am. J. M. Sc. **121**:27 (Jan.) 1901.

6. Opie, E. L.: Diseases of the Pancreas, ed. 2, Philadelphia, J. B. Lippincott Company, 1910. Baldwin, W. M.: The Pancreatic Ducts in Man, Together with a Study of the Microscopic Structure of the Minor Duodenal Papilla, Anat. Rec. **5**:197, 1911. Ruge, E.: Beiträge zur chirurgischen Anatomie der grossen Gallenwege, Arch. f. klin. Chir. **87**:47, 1908. Cameron, A. L., and Noble, J. F.: Reflux of Bile up the Duct of Wirsung Caused by an Impacted Biliary Calculus, J. A. M. A. **82**:1410 (May 3) 1924.

7. Rienhoff, W. F., Jr., and Pickrell, K. L.: Pancreatitis: An Anatomic Study of the Pancreatic and Extrahepatic Biliary Systems, Arch. Surg. **51**:205 (Nov.-Dec.) 1945.

8. Jones, R., Jr.: Etiology and Pathogenesis of Acute Hemorrhagic Pancreatitis, Am. J. M. Sc. **205**:277 (Feb.) 1943.

9. Mirizzi, P. L.: Functional Disturbances of the Choledochus and Hepatic Bile Ducts, Surg., Gynec. & Obst. **74**:306 (Feb.) 1942. Hulten, O.: Cholangiographie während der Operation, Deutsche Ztschr. f. Chir. **250**:484 (June 25) 1938. Leven, N. L.: Reflux into Major Pancreatic Duct During Cholangiography, Proc. Soc. Exper. Biol. & Med. **38**:808 (June) 1938.

Although it is frequently stated [10] that the theory of a common channel explains 60 to 70 per cent of the cases of the disease in man, this figure is undoubtedly too high.

Disease of the biliary tract and acute pancreatitis are frequently asociated.[11] This association is often used to lend support to the theory of a common channel.[12] That it is erroneous to use this association of diseases in support of this theory is shown clearly by our first case.

Originally, it was thought that a calculus impacted at the ampulla of Vater was responsible for the formation of a common channel in all cases of pancreatitis, but subsequent autopsy studies have shown that a stone is the obstructing agent in not more than 10 per cent of the clinical cases of this disease.[10a] Archibald [13] has done widely accepted work to show that segmental spasm of the sphincter of Oddi is the obstructing agent which creates the common channel in many clinical cases of the disease in the absence of stones. Recent work by Doubilet and Mulholland [13a] gives strong clinical support to Archibald's opinion. Edema or tumor of the papilla of Vater may be rarer causes.

The second important prerequisite is that once a common channel is formed the direction of flow in that channel must be toward the pancreas rather than the reverse. The direction of flow in such a system would depend on the relative pressures existing in the two ducts. It has been shown in animals that the maximal secretory pressure of the pancreas equals or exceeds that of the liver.[14] This is considered strong evidence against the common channel theory

10. (*a*) Dragstedt, L. R.; Haymond, H. E., and Ellis, J. C.: Pathogenesis of Acute Pancreatic Necrosis, Arch. Surg. **28**:232 (Feb.) 1934. (*b*) Lewison, E. F.: Acute Pancreatitis, ibid. **41**:1008 (Oct.) 1940. (*c*) Tatum, A. L.: The Influence of Bile on Autolysis, J. Biol. Chem. **27**:243, 1916. (*d*) Walters, W., and Cleveland, W. H.: Surgical Lesions of the Pancreas, Arch. Surg. **42**:819 (May) 1941.

11. Popper, H. L.: Etiology of Acute Pancreatitis, Am. J. Digest. Dis. **9**:186 (June) 1942. Bisgard, J. D., and Baker, C. P.: Studies Relating to Pathogenesis of Cholecystitis, Cholelithiasis and Acute Pancreatitis, Ann. Surg. **112**:1006 (Dec.) 1940.

12. Bockus, H. L.: Gastroenterology, Philadelphia, W. B. Saunders Company, 1946, vol. 3.

13. Archibald, E.: The Experimental Production of Pancreatitis in Animals as the Result of the Resistance of the Common Duct Sphincter, Surg., Gynec. & Obst. **28**:529, 1919.

13a. Doubilet, H., and Mulholland, J. H.: Recurrent Acute Pancreatitis, Ann. Surg. **128**:609, 1948.

14. (*a*) Mann, F. C., and Giordano, A. S.: Bile Factor in Pancreatitis, Arch. Surg. **6**:1 (Jan.) 1923. (*b*) Dragstedt and others.[10a]

because the onset of acute hemorrhagic pancreatitis usually occurs about two hours after a heavy meal, when the secretory activity of the pancreas is maximal. On the other hand, the secretory pressures are not the only factors determining the direction of flow. If the accessory pancreatic duct is patent and connects the main pancreatic duct with the duodenum, the secretory pressure of the pancreas would be nullified because the duodenal orifice of the accessory pancreatic duct is said to have no sphincter. The accessory pancreatic duct is patent at both ends in about 50 per cent of cases; hence bile can flow into the main pancreatic duct if the accessory pancreatic duct is patent at both ends.

The theory of a common channel is admittedly important, yet we and others feel that there are undoubtedly other factors which play a significant role in the initiation of the disease. Some studies have shown a very low per cent (3.5) [14a] of cases in which a common channel was possible. The literature records many cases of acute pancreatitis in which the ducts opened separately. The theory cannot explain cases of that type.

B. Obstruction of the Pancreatic Ducts: Rich and Duff [15] found metaplasia of the pancreatic ducts in 28.6 per cent of routine sections examined. In cases of acute pancreatitis, however, the routine sections revealed metaplasia in 55 per cent of the cases. They contended that metaplasia of the pancreatic ducts could cause obstruction, resulting in back pressure and rupture of the ductal-acinar system of the pancreas. Trypsin, thus liberated within the parenchyma of the gland, would then proceed to necrose the surrounding tissue and vessel walls and by enzymatic destruction cause acute hemorrhagic pancreatitis. The activation of trypsinogen to trypsin was felt to be unnecessary, as similar vascular necrosis could be experimentally produced by the injection of purified trypsin. Metaplasia of duct epithelium is only one mechanism for the production of ductal obstruction. The main thesis of Rich and Duff was that obstruction due to any one of several causes is an essential factor in the production of pancreatitis.

Yotuyanogi,[16] on the contrary, in an exhaustive study of pancreatic metaplasia, found that it occurred normally in the human being in at least 64 per cent of the specimens he examined. This conspicuous frequency of ductal metaplasia in the normal pancreas is inconsistent with the infrequency of acute pancreatic necrosis and would appear to

15. Rich, A. R., and Duff, G. L.: Experimental and Pathologic Studies on Pathogenesis of Acute Hemorrhagic Pancreatitis, Bull. Johns Hopkins Hosp. **58**:212 (March) 1936.

16. Yotuyanogi, S.: Metaplasie des Ausführungsgangepithels in menschlichen Pankreas, Mitt. ü. allg. Path. u. path. Anat. **9**:403, 1937.

conflict with the findings of Rich and Duff. It must be pointed out, however, that Yotuyanogi's study was conducted in cases in which a lower vitamin intake was probably a factor. (Metaplasia of pancreatic duct epithelium and of epithelium elsewhere in the body has been demonstrated to be associated with a deficiency of vitamin A.)

Obstruction to the outflow of pancreatic juice by such conditions as gallstones, pancreatic stones, stricture, edema and tumor undoubtedly accounts for many cases of acute pancreatitis.

Ch'in [17] expressed the opinion that the ultimate mechanism of acute hemorrhagic pancreatic necrosis seems to be an intrapancreatic activation of the normally inactive pancreatic juice. This intrapancreatic activation may be produced by several different mechanisms.

C. Trauma: Trauma has been known to cause acute pancreatitis.

D. Vascular Accidents; Thrombosis, Embolism or Rupture: It is not known how important primary changes in the blood vessels of the pancreas may be in the initiation of acute pancreatitis. Smyth [18] produced acute lesions simulating hemorrhagic pancreatitis by the injection of metallic mercury into one of the pancreatic arteries.

In a recent paper Popper and Necheles [19] discussed the important part which local vasospasm and ischemia may play in the development of acute pancreatitis. By ligating the pancreatic duct and injecting secretin, they were able to produce pancreatic edema consistently. They were unable to produce pancreatic necrosis until they also temporarily occluded the main pancreatic artery. They concluded that pancreatic edema and pancreatic necrosis are not merely different degrees of the same process but that another factor (vascular) is necessary to transform one into the other.

III. *A Combination of Factors.*—It is probable that a combination of two or more of the factors mentioned may produce acute pancreatitis by acting conjointly. It should also be mentioned that well confirmed clinical observations point in many cases to an association between pancreatitis and alcoholism.

REPORT OF CASES

CASE 1.—This case falls into the group in which a stone impacted in the ampulla of Vater causes pancreatitis. The stone did not produce a "common channel" by being impacted in the ampulla; it produced obstruction of the opening of the main pancreatic duct by external pressure.

17. Ch'in, K. Y.: Etiology and Pathogenesis of Acute Hemorrhagic Pancreatitis, Chinese M. J. **1**:1255 (Sept.) 1936.

18. Smyth, C. J.: Etiology of Acute Hemorrhagic Pancreatitis with Special Reference to Vascular Factors, Arch. Path. **30**:651 (Sept.) 1940.

19. Popper, H. L., and Necheles, H.: Transition of Pancreatic Edema into Pancreatic Necrosis, Surg., Gynec. & Obst. **87**:79 (July) 1948.

Laboratory Data in Relation to Postoperative Days

	Pre-operative	Day of Operation	1	2	3	4	5	6	7	8	9	10	11	12	13
White blood cell count	19,800	35,950	..	13,350	..	..	..	..	..	..	..	..	16,000	..	..
Polymorphonuclear cells	94%	.....	..	.....	..	..	..	..	..	..	..	..	.....	..	..
Hematocrit value	.....	.....	..	52	48	..	..	..	..	..	..	..	.....	..	..
Urine (sugar)	0	.....	3+	0	..	0	0	..	1+	0	..	..	.....	0	..
Urine (bile)	0	.....	0	0	..	..	..	..	..	..	..	..	.....	..	..
Blood sugar	.....	.....	193	188	173	163	173	..	155	..	..	..	.....	..	..
Van den Bergh	Direct	.....	..	.....	..	..	..	..	..	..	..	..	.....	..	..
Icteric index	.....	.....	21	.....	..	..	..	..	..	..	..	..	.....	..	..
Prothrombin time (% of normal)	.....	.....	39	46	63	..	..	..	41	..	..	..	.....	..	..
Serum amylase	.....	.....	..	316	..	58	..	..	95	73	..	..	.....	..	..
Serum calcium (mg.)	.....	.....	..	8.7	..	..	..	..	..	6.2	..	..	.....	..	7.5
Serum chlorides	.....	.....	..	.....	..	..	..	..	398	..	..	..	.....	..	..
Carbon dioxide-combining power	.....	.....	..	.....	..	..	..	..	60	..	..	..	.....	..	..
Urea nitrogen	.....	.....	..	.....	..	..	..	..	..	..	..	..	.....	14	..

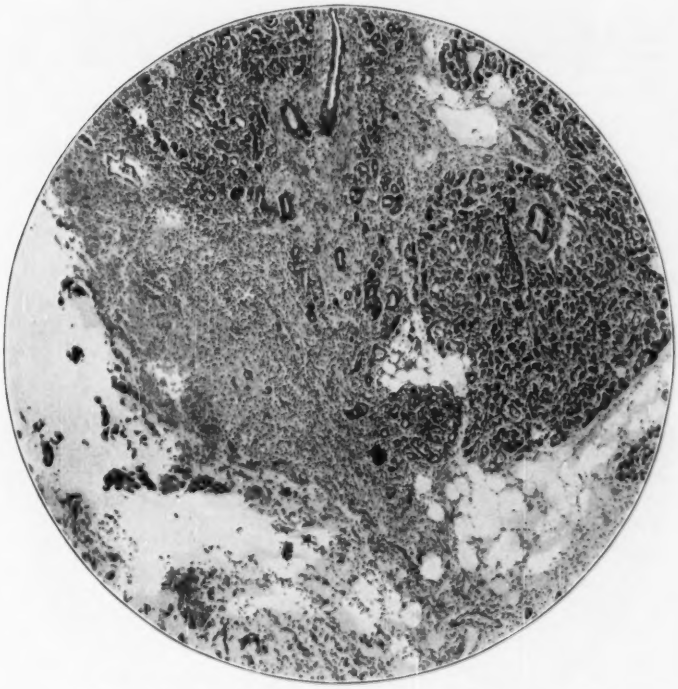


Fig. 1.—Area of pancreatic necrosis at the left of figure 2. × 40.

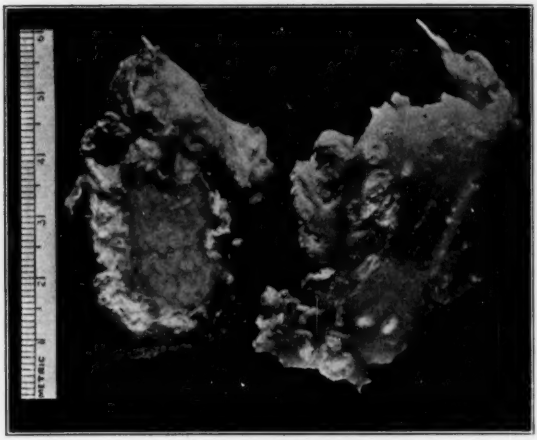


Fig. 2.—On the left is a lateral view of a mid-sagittal section of the pancreas showing the pancreas covered by a layer of necrosis inferiorly and anteriorly. The splenic artery and vein can be seen superiorly. At the right is shown a cross section of the indurated omentum with many areas of fat necrosis.

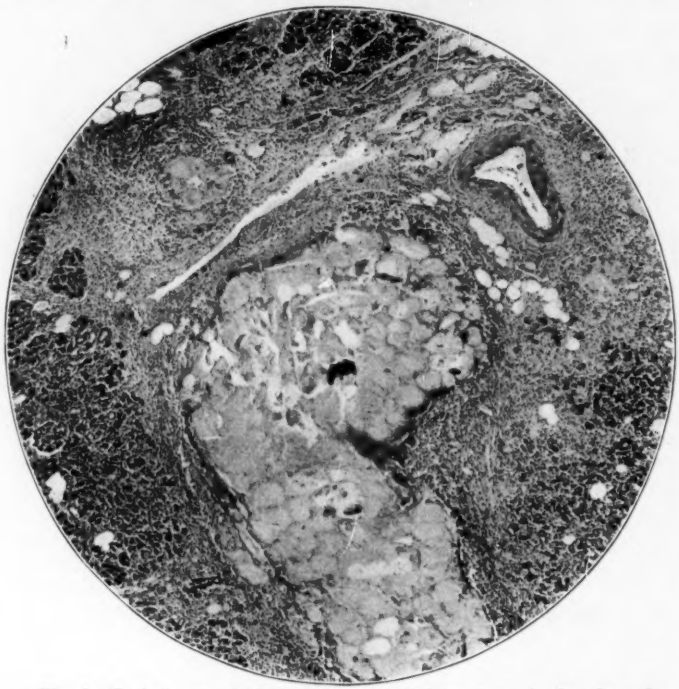


Fig. 3.—Typical area of fat necrosis surrounded by areas of otherwise uninvolved pancreas. × 30.

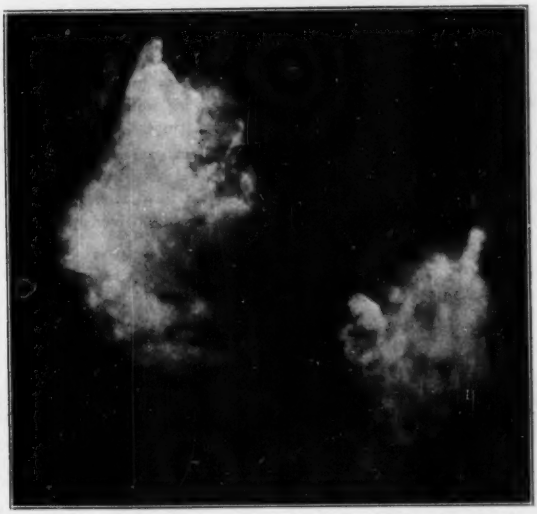


Fig. 4.—Roentgenograms showing calcium deposition in areas of fat necrosis in the omentum.

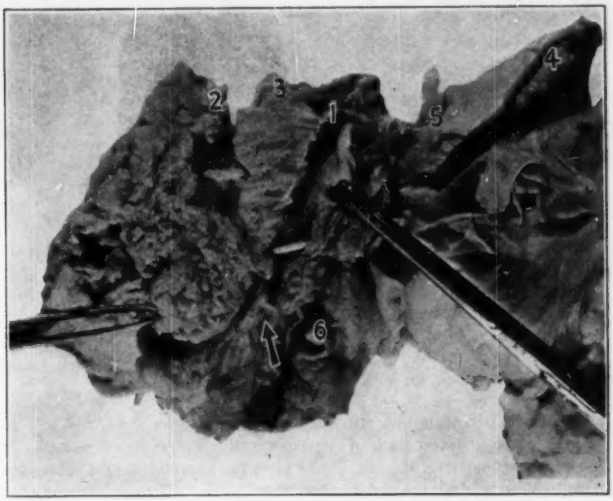


Fig. 5.—Stone impacted in the ampulla of Vater (see arrow) producing dilatation of the common bile duct [1] and complete obstruction of the main pancreatic duct.[2] (The larger stone lay in the common bile duct and has been removed.) *3*, a wedge of pancreatic tissue between the common bile duct and the main pancreatic duct; *4*, stomach; *5*, pyloris; *6*, duodenum. The arrow lies within the duodenum and points to the papilla of Vater.

A 61 year old white man noted the gradual onset of a steady pain three days before his admission to the hospital. The pain was under the site of an old cholecystectomy scar. He had had "indigestion" for some time. There was no history of clay-colored stools, vomiting or unusual ingestion of alcohol.

Past History.—Five years previously, the patient had undergone an operation on the biliary tract. The gallbladder was removed and contained many stones. There were several stones, varying up to 0.5 cm. in diameter, in the common duct, which was noted to be distended to about 1 cm. in diameter but only slightly

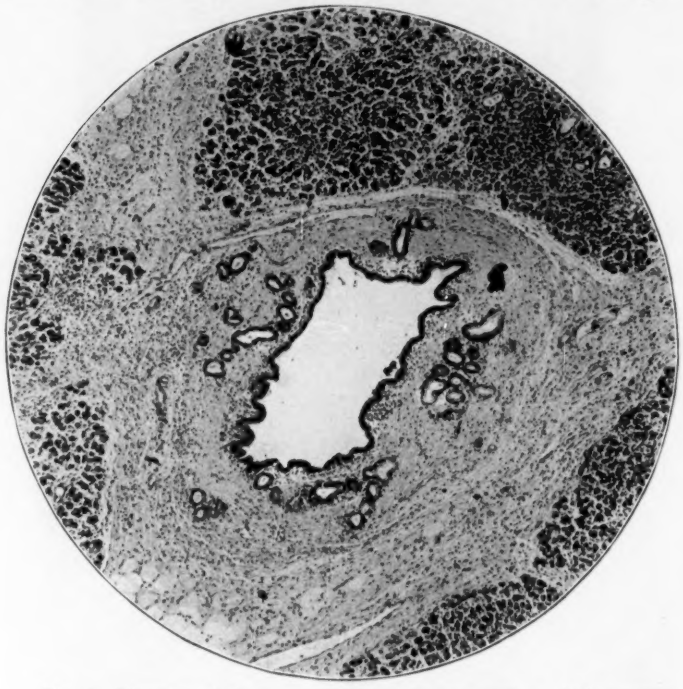


Fig. 6.—Dilatation of the pancreatic ducts, due apparently to back pressure caused by the obstruction. × 50.

thickened. Choledochotomy and removal of the stones were done, and a T tube was placed in the common duct. (The preoperative icteric index was 35.) On the fourteenth postoperative day the T tube came out by accident. He subsequently had profuse biliary drainage for two or three weeks. The drainage gradually decreased until it ceased completely by the fifth postoperative week. He was followed for several months, during which he was in good health. He was not seen again until the onset of his present illness, which occurred almost five years after his original operation.

Physical Examination.—The temperature was 100 F., the pulse rate 100 and the blood pressure 130 systolic and 70 diastolic. The significant observations were limited to the abdomen. There was moderate splinting of the abdominal musculature, and there was the suggestion of a mass in the right upper quadrant. There was a bluish discoloration to the right of the umbilicus.

Laboratory Data.—The white blood cell count was 19,800, with 94 per cent polymorphonuclear cells. The van den Bergh reaction was direct. The next day the white blood cell count rose to 35,950 and a laparotomy was done.

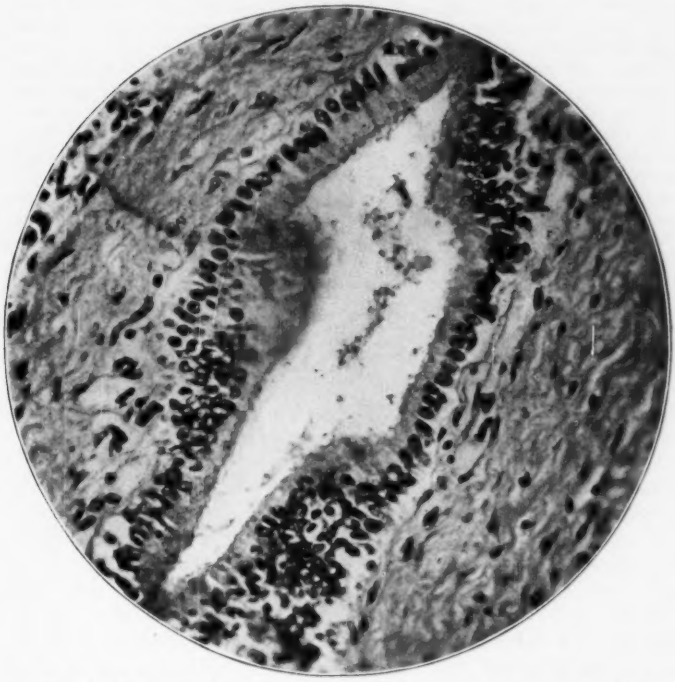


Fig. 7.—Higher magnification of a pancreatic duct showing areas of epithelial metaplasia. × 250.

Operation.—At operation the mass in the right upper quadrant was found to be an indurated mass of omentum with obvious areas of fat necrosis. A moderate amount of straw-colored fluid was present in the peritoneal cavity, and the typical red and white areas of acute hemorrhagic pancreatitis with many scattered areas of fat necrosis were present. A biopsy of the soap formation was made, and this subsequently confirmed the gross findings. The whole upper region of the peritoneum was indurated and edematous. Nothing more could be felt on palpation of the pancreas and common duct. The wound was closed in layers without drainage.

Postoperative Course.—The postoperative course was stormy. The temperature fluctuated between 100 and 101 F. The laboratory findings are shown in the accompanying table. The patient was treated with gastric suction, fluids intravenously, transfusions, insulin and vitamin K. The blood calcium level on the second postoperative day was 8.7 mg. per hundred cubic centimeters. He was given 1 Gm. of calcium gluconate intravenously daily.

Diarrhea developed, although the abdomen was silent on auscultation. His temperature continued to be around 101 F. Frequent fibrillary muscular twitches

Fig. 8.—This shows marked preexisting arteriosclerosis of the pancreatic vessels with almost complete obliteration of the lumen. × 30.

developed in both upper extremities. Chvostek's sign was negative. The carbon dioxide–combining power was 60 volumes per cent. Although the patient received calcium gluconate in 1, 2 and 3 Gm. doses daily, the fibrillary twitches persisted and the serum calcium content dropped to 6.2 mg. per hundred cubic centimeters on the eighth postoperative day.

Signs of bronchopneumonia developed, and the patient became irrational and died on the fifteenth postoperative day.

Postmortem Observations.—Autopsy showed acute hemorrhagic pancreatic necrosis (fig. 1) with a thick layer of necrotic tissue covering the pancreas as shown in figure 2. Many scattered areas of fat necrosis were seen in the indurated omentum (fig. 2), and one such area in the pancreas is shown in figure 3. The omentum was removed and a roentgenogram made to show the calcium deposition (fig. 4). There was a medium-sized abscess cavity walled off in the lesser omental sac. There were two stones in the distal end of the common bile duct. The larger stone was 2 cm. long and 1 cm. in diameter. The smaller stone was impacted in the ampulla of Vater in such a way that by external pressure it had completely closed off the opening of the main pancreatic duct (fig. 5). Figure 6 illustrates the dilatation of the pancreatic ducts, due apparently to back pressure caused by the obstruction. Figure 7 shows areas of metaplasia of the epithelium of the pancreatic ducts, but these areas were infrequently seen in several sections. Further dissection revealed complete thrombosis of the superior-posterior pancreaticoduodenal artery. Microscopic examination revealed arteriosclerosis to be present in all arteries. In most of the blood vessels the lumen remained patent (fig. 8), but in some the sclerotic process was completely occlusive. The superior-posterior pancreaticoduodenal artery was occluded by a well organized thrombus, with some inflammatory cells present. Multiple sections of this vessel were taken. Figure 9 shows all the layers of the vessel wall intact in one section, while figure 10 shows necrosis of part of the vessel wall in another section. The thrombotic vessel could be traced for several centimeters, so that the inferior-posterior pancreaticoduodenal artery may have also been completely occluded although this point was not definitely ascertained.

COMMENT

This case raises a number of interesting questions. Was the stone overlooked at the operation five years previously, and had it lain in the common duct quietly for all this time? Or had this common duct (described at the first operation as distended but only slightly thickened) formed another stone during the intervening five years? Stones may remain in the common duct for a long time and be fairly asymptomatic, so that in this case the more probable explanation is that the stones were overlooked at the time of the first operation.

It is often recommended that in operations for acute pancreatitis, the lesser sac should be drained and a T tube put in the common duct. Because of the induration and edema, these stones could not be palpated. While it would be a good routine to drain the common duct, in this case it would have been difficult to locate, much less open and drain. What is more, although a T tube in the common duct would have given some relief for the low degree of jaundice, it would have actually done nothing to relieve the obstructed pancreatic duct which was causing the disease. A drain in the lesser sac would have allowed egress to the subsequently developing abscess.

A third point of interest in this patient was the alteration in the blood calcium level. It ranged from 8.7 to 6.2 mg. per hundred cubic centimeters. It is known that the pancreatic lipase splits the fat into fatty acids and glycerin. The glycerin is absorbed, and the fatty acids

Figure 9

(See legend on opposite page)

combine with the serum calcium to form insoluble soaps, the chief constituents of the white areas of "fat necrosis." A recent study [20] has shown that the serum calcium value usually drops to the lowest level on the sixth day of the disease and that values below 7 mg. indicate a fatal prognosis. The lowest value in this patient was 6.2 mg. on the twelfth day of the disease. The prognostic value of the calcium level unfortunately proved to be correct in this case.

In view of the normal carbon dioxide–combining power, the tetany in this patient was undoubtedly due to the lowered serum calcium content. In spite of injection of 1, 2 and 3 Gm. of calcium gluconate intravenously daily, the serum calcium level remained low (7.5) and the tetany persisted. Although it would appear that 1 Gm. of calcium gluconate intravenously daily would be sufficient, since this is twice the amount of calcium in the whole blood stream, still this amount may be inadequate, because the large loss of calcium into the tissues is not readily compensated for by mobilization of calcium from the normal body stores.

In almost all the severe cases of pancreatitis reported in the literature the serum calcium level was lowered. This adds another laboratory finding which not only tends to substantiate the increase of blood and urinary diastase but also should be helpful in the difficulties involved in distinguishing pancreatic necrosis from pancreatic edema. There is real clinical value in attempting to distinguish pancreatic edema from pancreatic necrosis.[21] The patient with pancreatic edema will probably recover on conservative therapy. Whereas if the patient is suffering from true necrosis of the pancreas, the attacks will not subside and prolonged nonoperative therapy usually ends in death. In this group of patients, fortunately less common, operation should be carried out at an appropriate time, because without operation the mortality rate is high.[22] It should be acknowledged that the question of operation is unsettled and a careful study by Paxton and Payne [23] presents strong evidence of

20. Edmondson, H. A., and Berne, C. J.: Calcium Changes in Acute Pancreatic Necrosis, Surg., Gynec. & Obst. **79**:240 (Sept.) 1944.

21. Larson, E. E.: Acute Pancreatitis, West. J. Surg. **47**:371 (July) 1939.

22. Elman, Robert: Surgical Aspects of Acute Pancreatitis, J. A. M. A. **118**:1265 (April 11) 1942.

23. Paxton, J. R., and Payne, J. H.: Acute Pancreatitis, Surg. Gynec. & Obst. **86**:69 (Jan.) 1948.

EXPLANATION OF FIGURE 9

Fig. 9.—*A*, organized clot present in the superior-posterior pancreaticoduodenal artery with polymorphonuclear reaction in the clot and surrounding tissues. Note intact media of the artery. × 30. *B*, higher magnification of the wall of the vessel shown in *A*. × 50.

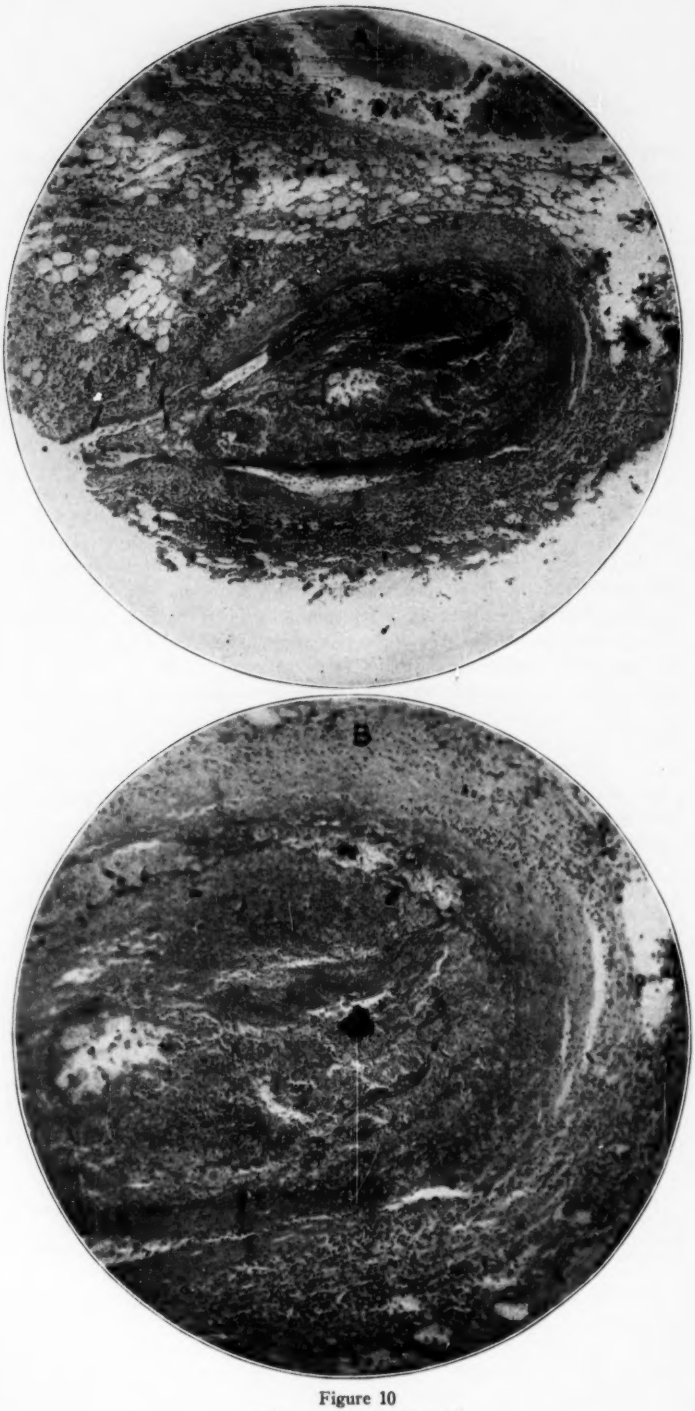


Figure 10

(See legend on opposite page)

superior results obtained by conservative management during both acute edematous pancreatitis and acute hemorrhagic pancreatitis.

A fourth point of interest that this case serves to emphasize is that infection is not usually an etiologic factor but a secondary complication. Whether the necrosis and autodigestion form the basis on which localized infection and abscess formation occur is not clear. The fact remains, however, that abscesses usually are found, as in this case, late in the course of the disease and undoubtedly should be considered a complication of the disease.

The final interesting point in this case was that there was complete thrombosis of the superior-posterior pancreaticoduodenal artery, with possible thrombosis of the inferior-posterior pancreaticoduodenal artery.

Microscopically, the arterial wall was intact except for one area which showed necrosis in accordance with the findings of Rich and Duff. They described activated trypsin producing necrosis of the pancreatic parenchyma and then producing necrosis of part of the blood vessel wall to produce the characteristic hemorrhages. This attack on the wall of the blood vessel from the outside could produce necrosis of the adventitia, media and intima and finally result in thrombosis of the blood vessel. In this case the arterial wall was intact except for one area of necrosis.

Obstruction of the pancreatic duct by itself does not produce acute pancreatitis. Ligation of the pancreatic ducts produces gradual, complete atrophy of the pancreatic tissue except for the islands of Langerhans. In order to produce acute pancreatitis, therefore, another factor is necessary.

In recent experimental work,[19] pancreatic edema could be produced regularly in dogs by ligation of the pancreatic ducts and administration of large doses of secretin intravenously. Although pancreatic edema could be produced regularly by this method, it was not possible to produce hemorrhagic pancreatitis or pancreatic necrosis without temporarily clamping off the main pancreatic (gastroduodenal) artery for fifteen minutes. The authors concluded that since they could not produce pancreatic necrosis by increasing or prolonging the edema produced by secretin it is apparent that pancreatic necrosis or hemorrhagic pancreatitis is not merely an advanced form or a later stage of pancreatic edema, as is frequently thought, but that an additional vascular factor is necessary.

EXPLANATION OF FIGURE 10

Fig. 10.—*A*, other sections of the same artery showing necrosis of the blood vessel wall in the lower right hand corner of figure 9. × 30. *B*, higher magnification of the wall of the vessel shown in *A*. × 50.

Although there is no way of knowing, perhaps the arterial thrombosis preceded the pancreatitis and was a factor in producing it rather than a result of it. It is more likely, in our opinion, that the thrombosis resulted from the pancreatitis because of the microscopic evidence of necrosis of the arterial wall.

CASE 2.—A 36 year old white woman gave a history of attacks of epigastric pain and pains in the right upper quadrant periodically for ten years. During this time she noticed belching after meals and intolerance to fried foods. During the past two months these attacks became more frequent and lasted two or three hours. Cholecystograms, taken two months previously, revealed gallstones.

The day before her admission the patient ate fried fish for dinner and two hours later a dull ache developed in the epigastrium which gradually increased in severity. The pain radiated to the right scapula. She was nauseated but did not vomit. There was no history of jaundice.

At operation a thickened gallbladder with stones was found. The pancreas was thickened, and the omentum was studded with typical white plaques of fat necrosis. Cholecystectomy was done, and the common duct was drained. There were no stones in the common duct. Biopsy of the omentum showed fat necrosis on microscopic examination.

A postoperative cholangiogram showed no stones in the common duct. The catheter was removed on the seventeenth postoperative day, and the wound healed completely.

CASE 3.—A 64 year old white woman was admitted to the hospital with a history of epigastric pain, nausea and vomiting of two days' duration. The pain was intermittent and so severe that it caused the patient to double up. She had had two previous attacks; one was four months and the other about eight months previous to the time of her admission to the hospital.

Examination revealed moderate rigidity of the entire abdomen, with a mass in the epigastrium. Soon after admission the patient went into shock, and in spite of supportive therapy she died the next day.

At autopsy there was about 400 cc. of bloody fluid in the peritoneal cavity. The pancreas was larger and firmer than normal, and its surface was discolored by necrosis and hemorrhage. There were many scattered white spots of fat necrosis. The gallbladder was normal, and there were no stones in the bile ducts or pancreatic ducts

CASE 4.—A 53 year old white woman gave a two year history of "liver attacks" consisting of epigastric pain, "gas," nausea and vomiting. She had had an attack about one week prior to her admission to the hospital followed by jaundice and pruritis. She had had jaundice accompanying two previous attacks.

Examination revealed exquisite tenderness in the epigastrium and the left upper quadrant and a questionable mass extending across the abdomen from the epigastrium to the left upper quadrant.

Laboratory examination revealed a serum amylase content of 213 mg., an icteric index of 23.4 units, no bile in the urine and a blood sugar content of 73 mg. per hundred cubic centimeters.

The patient improved on medical management and was sent home for one month. A cholecystogram showed a nonfunctioning gallbladder full of stones. She was readmitted to the hospital, and cholecystectomy was done. The common duct was explored, and no stones were found. A T tube was inserted. The pancreas was enlarged and indurated.

A delayed cholangiogram showed no stones in the common duct, and the T tube was removed one month after operation. The wound healed without delay, and the patient made an uneventful recovery.

CASE 5.—A 58 year old white woman experienced sudden, severe, constant epigastric pain several hours after a fish dinner. The pain radiated to the back between the shoulder blades. She also had "gas" with eructations and flatulence and vomited several times. She had undergone cholecystectomy and appendectomy thirteen years before. Her present attack resembled her previous gallbladder attacks. A diagnosis of acute pancreatitis was made.

Physical examination revealed a distended abdomen with epigastric tenderness. No masses were palpated. Laboratory examination revealed a serum amylase content of 348 units. The patient improved on medical management.

COMMENT

Four of the 5 patients had undergone operations on the biliary tract at some time during their history. The one patient who had not was admitted to the hospital in a serious condition, went into shock and died in a short time. It is entirely possible that if there had been sufficient time, a history of disease of the biliary tract might have also been elicited.

SUMMARY

The pathogenesis of acute hemorrhagic pancreatitis is discussed from the standpoint of what appear to be the more logical views and the most convincing research.

The experience with acute hemorrhagic pancreatitis at the Alexander Blain Hospital during the past five years has been reviewed.

It would appear at the present time that for acute hemorrhagic pancreatitis to occur there must usually be not only some obstruction to the main pancreatic duct but also a vascular abnormality within the parenchyma of the pancreas.

The importance of an interest in the pathogenesis of this lesion to the surgeon is illustrated. An understanding of the pathogenesis of acute pancreatitis will aid in the diagnosis as well as in the intelligent therapy of the condition.

The mechanism of the production of hypocalcemia and its importance in differentiating the two main types of acute pancreatitis have been emphasized.

2007 Wilshire Boulevard, Los Angeles 5.

REEVALUATION OF ETHYL ALCOHOL AS A GERMICIDE

PHILIP B. PRICE, M.D.
SALT LAKE CITY

ETHYL alcohol remains the most popular of skin disinfectants and rightly so, because by and large it is the best. Inexpensive, readily obtainable, harmless to the skin and bacteriologically potent, its chief deficiency lies in its inability to kill spores—a deficiency shared by all the commonly used skin disinfectants. That its bactericidal power varies with the concentration of the solution used is well known, but what constitutes the most effective alcohol-water ratio has long been a moot question. The correct answer to that query, though a detail of surgical technic, is a matter of considerable practical importance.

According to traditional opinion (Epstein [1]) 50 per cent by volume is best. Harrington [2] found, however, that 60 to 70 per cent by volume is the optimum concentration against dry test bacteria and that stronger concentrations are equally efficacious when the bacteria are wet. Beyer,[3] who was first to point out the advantages of preparing alcohol solutions by weight rather than by volume, observed that 70 per cent by weight was by far the most powerful concentration against dry staphylococci. His conclusions were corroborated by Gregersen,[4] but Christiansen [5] concluded that 80 per cent by weight was better. Still other opinions were voiced by investigators. It is not surprising, therefore, that until recently there has been no uniformity of opinion or practice in the use of alcohol as a disinfectant.

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From the Department of Surgery, University of Utah College of Medicine.

1. Epstein, F.: Zur Frage der Alkoholdesinfection, Ztschr. f. Hyg. u. Infectionskr. **24**:1, 1897.

2. Harrington, C.: The Germicidal Action of Alcohol, Boston M. & S. J. **148**:548, 1903.

3. Beyer, A.: Alkoholdesinfektion, Ztschr. f. Hyg. u. Infektionskr. **70**:225, 1911.

4. Gregersen, J. P.: Untersuchungen ueber die desinfizierende Kraft der desinfizierenden Stoffe im Verhältnis zu ihrer Konzentration, Centralbl. f. Bakteriol. (abt. 1) **77**:168, 1916.

5. Christiansen, J.: Zur Theorie und Praxis der Alkoholesinfektion, Ztschr. f. physiol. Chem. **102**:275, 1918.

In 1938 the serial basin method of measuring the degree of skin disinfection was introduced [6]—a quantitative in vivo method which tests disinfectants under conditions of actual use. On my own hands and arms, 70 per cent alcohol by weight was found to be not only the optimum concentration but a powerful skin disinfectant as well.[6c] Similar results were reported by Pohle and Stuart,[7] Pillsbury, Livingood and Nichols [8] and others, who used the serial basin test or some modification of it. Seventy per cent alcohol is at present widely employed in hospitals of the United States.[9] Skepticism is still expressed in some quarters, however. Hatfield and Lockwood,[10] for example, who used a modification of the serial basin test, agree that 70 per cent by weight is strongly germicidal but claim that 95 per cent by volume is even more effective, and Palmer [11] stated that "while some authorities still consider 70% solution (by weight) most effective, recent [in vitro] studies indicate that the differences in the germicidal power of 60% and 90% ethyl alcohol are not great."

These persistent differences of opinion have led me to repeat my previous work on a larger scale, testing various dilutions of alcohol in vitro as well as on the hands and arms of several subjects. The purpose of this paper is to report in summary form the results of that study. It would be a happy outcome for all concerned if the question of what strength of alcohol is best for disinfectant purposes could be settled once and for all.

IN VITRO STUDIES

Most in vitro measurements of disinfectant action are concerned only with bacteriostatic dilutions of antiseptics and exposure times necessary to obtain negative cultures. Such tests are at best crude methods

6. (*a*) Price, P. B.: The Bacteriology of Normal Skin: A New Quantitative Test Applied to a Study of the Bacterial Flora and the Disinfectant Action of Mechanical Cleansing, J. Infect. Dis. **63**:301, 1938; (*b*) New Studies in Surgical Bacteriology and Surgical Technic, with Special Reference to Disinfection of the Skin, J. A. M. A. **111**:1993 (Nov. 26) 1938; (*c*) Ethyl Alcohol as a Germicide, Arch. Surg. **38**:528 (March) 1939.

7. Pohle, W. D., and Stuart, L. S.: The Germicidal Action of Cleansing Agents: A Study of a Modification of Price's Procedure, J. Infect. Dis. **67**:275, 1940.

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9. Price, P. B.: Current Methods of Skin Disinfection in American Hospitals, to be published.

10. Hatfield, C. A., and Lockwood, J. S.: An Evaluation of Some of the Materials Commonly Used for the Preoperative Preparation of the Skin, Surgery **13**:931, 1943.

11. Palmer, D. H.: Germicides, Antiseptics and Disinfectants for Hospital Use, New York, Hospital Bureau of Standards and Supplies, Inc., 1948.

of measuring germicidal power, for the end point is not sharp and no account is taken of killing action prior to complete sterilization. The results obtained in the tests are often meaningless from the standpoint of surgical technic.

In the present investigation a previously described method of germicidal evaluation [6c] was employed, which consists of dropping 0.02 cc. of an aqueous suspension containing a known number of test bacteria into 2 cc. of alcohol in a sterile stainless steel teaspoon. At the end of the test period, which is measured with precision, the antibacterial action of the alcohol is brought to a sudden stop by plunging the spoon and its contents into a beaker of 198 cc. of sterile water. The number of surviving bacteria is then determined by means of pour plate counts. This test permits optimum, uniform contact between alcohol and wet bac-

TABLE 1.—*Germicidal Effect of Ethyl Alcohol on Staphylococcus Albus* *

Duration of Contact Between Germicide and Bacteria	Concentration of Alcohol, per Cent by Weight									
	10	20	30	40	50	60	70	80	90	99
0 (control)....	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0
1 sec.....	108.3	104.5	80.2	71.4	68.8	59.5	27.1	29.9	68.8	61.9
10 sec.....	86.7	94.6	65.8	77.6	41.2	34.9	26.6	26.6	37.3	60.7
30 sec.....	106.5	92.7	50.2	47.2	35.7	18.4	21.2	34.1	48.2	48.7
1 min.....	127.5	91.1	49.8	35.5	22.7	9.3	18.6	14.9	54.4	46.8
5 min.....	108.4	89.9	42.2	14.1	15.5	12.2	21.7	24.4	41.9	26.2
10 min.....	90.4	73.6	24.6	14.7	9.9	13.5	23.4	20.1	46.0	41.8

* The numbers in the table indicate the per cent of test organisms surviving after contact with alcohol.

teria as well as accurate control of duration of contact; by adequate dilution it eliminates any effect of bacteriostasis in cultures, and it measures quantitatively the rate of destruction of the test bacteria by the germicide.

Various concentrations of alcohol were studied. The tests were all carried out uniformly at room temperature (about 25 C.). Three types of micro-organisms were used: Staphylococcus albus obtained from the resident flora of the skin, Staphylococcus aureus and Escherichia coli from stock laboratory cultures. In preparing suspensions, twenty-four-hour broth cultures were used; these were diluted to such a degree that each drop (0.02 cc.) of suspension contained approximately 100,000 bacteria.

Results of this study are summarized in tables 1, 2 and 3 and figures 1 and 2.

It can be seen at a glance that time was a factor of prime importance in these tests. Each solution of alcohol exhibited a specific rate of bacterial destruction, and the rate increased as the optimum concentrations of alcohol were approached. The bactericidal effect of the stronger solutions of alcohol during the first second of contact is a remarkable phenomenon.

TABLE 2.—*Germicidal Effect of Ethyl Alcohol on Staphylococcus Aureus* *

Duration of Contact Between Germicide and Bacteria	Concentration of Alcohol, per Cent by Weight									
	10	20	30	40	50	60	70	80	90	99
0 (control)....	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0
1 sec.....	71.0	96.0	92.5	81.2	47.1	11.0	15.0	10.2	18.7	4.5
10 sec.....	161.0	103.6	69.0	53.3	35.0	7.8	4.6	7.1	6.1	18.7
30 sec.....	181.0	78.5	50.0	28.7	22.8	18.7	0.5	0.5	0.1	25.0
1 min.....	264.0	81.2	64.6	16.5	5.0	0.4	1.9	3.8	0.4	4.9
5 min.....	100.0	63.1	16.1	0.5	1.1	0.8	0.0	0.0	0.1	1.8
10 min.....	110.0	53.1	3.5	0.5	0.0	1.2	0.0	0.0	0.2	6.2

* The numbers in the table indicate the per cent of test organisms surviving after contact with alcohol.

TABLE 3.—*Germicidal Effect of Ethyl Alcohol on Escherichia Coli* *

Duration of Contact Between Germicide and Bacteria	Concentration of Alcohol, per Cent by Weight									
	10	20	30	40	50	60	70	80	90	99
0 (control)....	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0
1 sec.....	107.5	106.0	102.1	92.3	54.3	37.1	16.5	5.2	1.8	86.8
10 sec.....	98.4	92.1	90.8	80.0	49.8	27.5	9.0	10.3	0.0	87.4
30 sec.....	127.5	95.8	62.4	54.3	30.2	17.8	2.9	0.0	0.1	86.8
1 min.....	103.0	91.6	39.1	38.1	35.9	2.1	1.7	1.7	0.4	104.1
5 min.....	91.7	72.0	12.8	1.0	0.7	0.0	0.6	3.4	0.1	100.2
10 min.....	109.0	81.8	0.4	0.8	0.0	0.0	0.3	0.0	0.2	20.2

* The numbers in the table indicate the per cent of test organisms surviving after contact with alcohol.

On the basis of this test, 60, 70, 80 and 90 per cent solutions of alcohol appear to have approximately equal germicidal values. Against staphylococci, 70 and 80 per cent solutions of alcohol seem to be most effective, whereas 90 per cent appears to be slightly more germicidal for Bacillus coli; however, these differences are slight and may well be within the range of normal variation and technical error. The mean results of the three tables are compared in figure 2. Absolute alcohol is clearly less strongly bactericidal than the 70 and 80 per cent strengths. Staph. albus appears to be a hardy bacterium, less susceptible than the others to the killing action of alcohol.

These results and conclusions are valid, however, only for the test bacteria under the experimental conditions described; they do not necessarily indicate what bactericidal effects similar solutions of alcohol

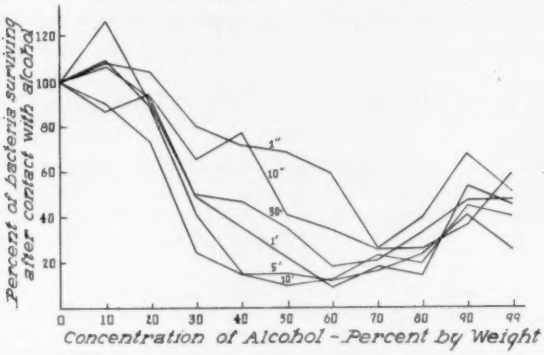

Fig. 1.—Data in table 1 shown graphically. The topmost curve, for example, shows the killing effect of various concentrations of alcohol with only one second contact. The remaining curves show the results of longer exposures.

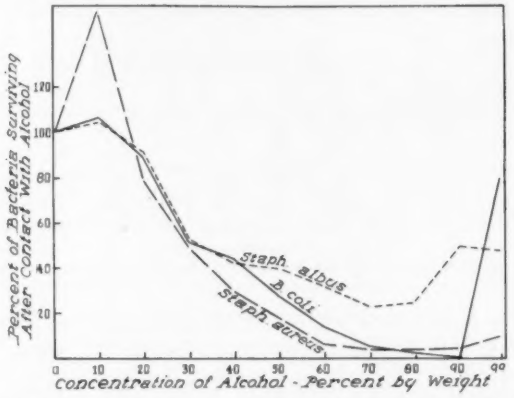

Fig. 2.—The disinfectant action of various strengths of alcohol against three sorts of bacteria in suspension. For the sake of easy comparison, in tables 1, 2 and 3 the six tests with each solution of alcohol are taken together and the averages are plotted here.

have when applied to skin. It cannot be emphasized too strongly that reliable evaluation of skin disinfectants requires that they be tested under conditions of actual use.

DISINFECTION OF THE SKIN

The serial basin method used in this study has been described in detail in previous papers,[6a,c] and its advantages over other methods have been enumerated.[12] It is an in vivo test which measures quantitatively, under conditions of actual use, the disinfectant action of germicides in terms of reduction of the bacterial flora of the hands and arms.

The strengths of alcohol tested were 20, 40, 60, 70 and 80 per cent, all by weight, as well as 95 per cent by volume (commercial alcohol; approximately 92.3 per cent by weight) and absolute alcohol (approximately 99 per cent by weight). After the hands and arms had been scrubbed in the first series of basins and rinsed in an additional basin of sterile water to remove residual soap, they were dried with sterile

TABLE 4.—*Germicidal Effect of Ethyl Alcohol on the Hands and Arms* *

	Concentration of Alcohol, per Cent by Weight						
Subjects	20	40	60	70	80	92.3	99
A.....	62.5	26.5	16.6	14.7	24.2	16.7	....
	....	....	....	3.5	23.1	26.7	....
	....	....	....	8.3	21.6	62.4	....
	....	....	....	...	....	16.3	....
B.....	91.2	69.6	14.1	6.8	5.1	1.2	5.1
	....	....	....	8.1	6.9	2.7	6.8
	....	....	....	14.7	12.2	7.1	2.9
	....	....	....	....	....	14.5	...
	....	....	....	....	....	11.7	...
	....	....	....	....	....	7.8	...
C.....	159.0	83.5	69.0	12.7	20.9	10.7	...
	118.0	76.7	25.4	29.2	6.4	11.3	...
	....	....	19.7	19.0	5.0	17.6	...
	....	....	....	....	...	8.6	...
D.....	....	44.4	....	11.4	2.6	21.2	...
	....	....	....	5.4	10.0	7.9	...
	....	....	....	1.4	...	1.4	...

* The numbers in the table indicate the per cent of bacteria surviving on the skin after two minutes' contact with alcohol. The results are those of fifty-seven separate tests.

gauze and by evaporation and were washed without friction for one hundred and twenty seconds in a freshly prepared alcohol solution at room temperature (25 C.). The action of the alcohol was stopped suddenly at the end of that period by plunging the hands and arms quickly into sterile water. Scrubbing was then resumed in a second series of basins. From bacterial counts of the washings the quantity of the flora and the amount to which it was reduced by the disinfectant were calculated by methods described elsewhere.[13]

Four selected subjects were used in these tests—a surgeon, a surgical fellow working in the laboratory, a medical student and a secretary.

12. Price, P. B., and Bonnett, A.: The Antibacterial Effects of G-5, G-11, and A-151, with Special Reference to Their Use in the Production of a Germicidal Soap, Surgery **24**:542, 1948.

13. Bernstein, L. H. T.: Technic for Studying the Epithelial Cells of the Skin in Relation to Disinfection, J. Invest. Dermat. **2**:49, 1948. Price.[6a,c]

The surgeon was accustomed to disinfect his hands frequently, the fellow and the student occasionally and the secretary rarely. The habitual flora of the 4 persons differed in amount and to some extent in quality also. The resident bacterial populations of the unwashed hands and arms of the 4 subjects (ample time being allowed for full regeneration of the flora if the hands had been disinfected previously) averaged 9.1, 45.5, 10.7 and 62.5 million respectively. The rate of reduction of the flora by scrubbing also varied considerably with the different persons. Some of the hands had persistently higher proportions of pigment-producing bacteria than other hands had. The skin of the 4 subjects varied also in smoothness, keratinization, hairiness, oiliness, moisture, pigmentation and surface temperature.

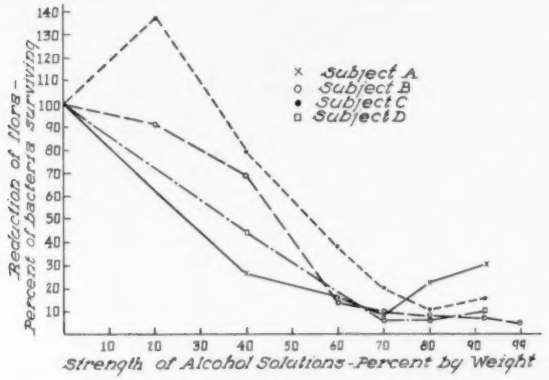

Fig. 3.—Results of washing the hands and arms for two minutes in various strengths of alcohol. These curves represent the mean values of table 4.

The results of fifty-seven separate tests conducted during a period of more than one year are summarized in table 4. The figures in the body of the table indicate reductions of flora in individual tests, expressed in percentages, the flora immediately before alcohol was used in each test being considered 100 per cent and sterility of the skin as 0 per cent. For example, subject A, in the first test, by washing in 20 per cent alcohol for two minutes, reduced his bacteria from 2,868,000 to 1,792,000, or from 100 to 62.5 per cent, and in the second test, by washing in 40 per cent alcohol for two minutes, he reduced the bacteria from 3,870,000 to 1,026,000, or from 100 to 26.5 per cent.

The average degree of disinfection for each subject and each concentration of alcohol is shown graphically in figure 3. It will be seen

that in general solutions of alcohol increased in skin disinfectant power as their concentration increased, up to 70 per cent by weight; thereafter all concentrations had much the same effect. There were individual variations. Subject A found 70 per cent to be the optimum concentration for his hands (which confirmed his previous results),[6b, c] whereas subject B obtained the best average effect from absolute alcohol.

ALCOHOL IN WOUNDS

Although no satisfactory method is available as yet for measuring directly and quantitatively the antibacterial effects of chemical agents in wounds, indirect evidence can be adduced to show that alcohol in wounds is not only valueless but harmful.

Concentrations of alcohol strong enough to kill bacteria also coagulate serum and tissue proteins. Bacteria present may be protected by the coagulum, or the alcohol may be used up in the process of coagulation, as the following tests imply.

Bacteria suspended in serum were exposed to various strengths of alcohol for measured periods by means of the spoon method already described. The presence of serum greatly reduced the germicidal effect of all strengths of alcohol as compared with that in parallel tests using aqueous suspensions of the same organisms. The degree of neutralization depended on the relative amounts of alcohol and serum employed in making the tests.

These results are in line with clinical observations. Alcohol in wounds is extremely painful and aggravates inflammation; it inhibits marginal proliferation of epithelium, stimulates fibrosis and delays healing, and it does not usually reduce the bacterial content of wounds, so far as that can be measured by means of smears and cultures.

COLD STERILIZATION OF INSTRUMENTS

For many reasons alcohol is an unsatisfactory agent with which to attempt cold sterilization of "sharps" and other instruments. Spores are not killed. Even vegetative bacteria may escape destruction if they are hidden in the joint of scissors, or are protected by residual grease or blood clot or if they lie in some inaccessible part of a complex instrument to which the alcohol does not penetrate. Alcohol, or any other cold solution for that matter, should not be expected to sterilize the lumen of a needle dropped into it. A momentary dip of an instrument into alcohol is a futile gesture; yet prolonged soaking tends to rust metal.

No ideal germicidal solution for cold sterilization of instruments has yet been discovered. Some of the better preparations in current use contain alcohol as an ingredient.

COMMENT

Critical reference has been made already to in vitro tests in which a sterile culture is the sole criterion of germicidal effect and in which germicidal power is gaged by the concentration of the disinfectant required to give negative cultures after contact with the test organism for arbitrary lengths of time, e. g., more than five but less than ten minutes. It is instructive to review tables 1 to 3 from that viewpoint. Had broth cultures been employed in these experiments instead of poured agar plates, it is clear that few negative cultures would have been obtained, and in consequence much of the progressive killing effect of the alcohol, so clearly demonstrated in the tables, would have gone undetected.

Figures 1, 2 and 3 agree in showing that 70, 80, 90 and 92.3 per cent solutions of alcohol have about equal germicidal power, both on skin and against bacteria suspended in water. But the rate of destruction is far slower on the skin for all concentrations of alcohol. Additional experiments have been performed which show that alcohol on skin usually reduces the flora at logarithmic rates. For example, if a given solution reduces the flora to 50 per cent of its original size in one minute, washing for a second minute will reduce the remaining flora by one half, or to 25 per cent of the original size, and washing for a third minute will reduce the flora further to 12.5 per cent of the original number. The rate of killing of bacteria in aqueous suspension is more rapid, however, approximating a "log log" rate.

Bernstein [13] has shown that the disinfectant action of alcohol on skin is a real killing effect and not, as some have claimed, an illusion due to "hardening" of the epidermis.

Although the serial basin test for skin disinfection is not highly accurate, it does give approximately correct results. The different effects obtained by the same person using the same strengths of alcohol (table 4) are probably due in part to variations from time to time in size and quality of the cutaneous flora and in part also to the changing conditions of the skin during the months when these experiments were being carried on. On the whole, agreement is sufficiently close (fig. 3) to justify the conclusion that solutions of alcohol 70 per cent by weight and stronger are all effectively germicidal when applied to healthy skin.

The experiments reported in this paper do not demonstrate that 70 per cent alcohol by weight has any germicidal advantage over the higher concentrations of alcohol so far as the average user is concerned. The 70 per cent solution has other advantages, however, that may be worth considering. Volume for volume, it is somewhat cheaper than the more concentrated solutions; it spreads more evenly over the skin and evaporates more slowly, and it is more completely innocuous, since alcohol at that concentration neither dehydrates the skin nor extracts its lipids.

A recommendation previously made [6b, c] may therefore be repeated: In preparation for operation, the hands and arms, after a thorough preliminary scrub, should be dried on a sterile towel. They should then be washed briefly in 95 per cent (by volume) alcohol, and finally they should be washed for two or three minutes in a basin of alcohol 70 per cent by weight, washcloth friction being used to enhance the already powerful disinfectant action of the germicide. The main reason for recommending the wash in 95 per cent alcohol is to remove all remaining traces of water from the skin and thus avoid dilution and weakening of the potent 70 per cent solution of alcohol. An incidental advantage is that this step adds to the total germicidal effect, especially in persons, like subject B, whose cutaneous bacteria happen to be more susceptible to the higher concentrations of alcohol.

SUMMARY AND CONCLUSIONS

A new effort has been made to settle finally the old but still controversial question of the germicidal value of ethyl alcohol. This is a matter of practical importance because alcohol is universally employed as a skin disinfectant and as a solvent for other germicidal agents and not infrequently also as the solution of choice for cold sterilization of "sharps" and other instruments.

In vitro studies, using the quantitative "spoon test" with bacteria in aqueous suspension, have shown that some concentrations of alcohol are impotent but that others are strongly and rapidly germicidal. In general, 10 and 20 per cent solutions by weight have little or no bactericidal effect in ten minutes or less at room temperature; 30, 40 and 50 per cent solutions show progressively greater germicidal power, and 60 to 90 per cent solutions by weight are all strongly and rapidly bactericidal, much of the killing effect apparently taking place during the first few seconds of contact. Absolute alcohol is somewhat less effective. Staph. albus, obtained from the resident flora of the skin, was observed to be more resistant to ethyl alcohol than either Staph. aureus or E. coli taken from stock laboratory cultures. Spores of various sorts were found to be highly resistant to all concentrations of alcohol at room temperature, although vegetative forms of the same organisms were killed.

Various concentrations of alcohol have also been tested thoroughly under conditions of actual use on the hands and arms of several persons. Solutions 60 per cent by weight and stronger were all shown to be efficient skin disinfectants. The optimum concentration varied with different persons, and even in the same person from time to time, probably because of variations in the flora and condition of the skin.

Seventy per cent alcohol by weight is still believed to be the solution of choice for disinfection of the skin. In addition to being powerfully germicidal, this solution spreads well, dries slowly, does not extract cutaneous fats, is almost perfectly innocuous on healthy skin and is proportionately less expensive than higher concentrations. It is recommended that the operator, in preparing for surgical procedures, should, after a thorough scrub, dry his hands and arms with a sterile towel and then wash in two solutions of alcohol with washcloth friction, first briefly in a basin of 95 per cent by volume (commercial) alcohol and then for two or three minutes in a basin of 70 per cent alcohol by weight. If the skin is healthy, that simple routine will scarcely fail to reduce its bacterial count greatly (to approximately 1 or 2 per cent of the original number), whatever the initial size or specific composition of the flora.

Ethyl alcohol should not be used as a disinfectant in wounds or on raw surfaces, for it is painful, it injures the tissues and its antibacterial action is neutralized by proteins present in the wound.

Since simple solutions of ethyl alcohol tend to rust metal and cannot be depended on to kill spores, they are not satisfactory agents for cold sterilization of instruments.

VITALLIUM® RECONSTRUCTION OF THE MALAR BONE

WILLIAM P. KLEITSCH, M.D.
LINCOLN, NEB.

DEPRESSED fractures of the malar bone offer a source of annoyance to the surgeon because of the facial asymmetry which results if they are overlooked or neglected. The main characteristic of the deformity is a loss of the malar prominence, which results in a falling away or flattening of the cheek on the affected side. Ptosis and lateral displacement of the ipsilateral eye due to loss of support furnished by the inferolateral orbital walls further aggravate the condition. To prevent such disfigurement, early reduction and support of the malar bone in a reduced position is indicated. There are many procedures described for doing this, and the average case is readily handled by the indicated technic. Ordinarily little or no residual deformity will remain. Complete or partial loss of the malar bone is a condition seldom seen in civilian life. During the late war, however, it was impossible to see many maxillofacial wounds without seeing at least one in which loss of the malar bone played a role.

The reason for the frequency of loss of the malar bone in war experience hinges on the extensive use of high explosives in modern warfare. The fragments produced by detonation of high explosive shells have an extremely high velocity and consequently a high energizing potential. In other words, such missiles impart a portion of their energy to objects with which they come in contact and set them in motion as secondary missiles. This effect was often seen in war wounds due to high velocity missiles and particularly often in cases of maxillofacial wounds, in which teeth and small bone fragments made ideal secondary missiles.

There are two additional reasons inherent within the anatomy of the bone itself which make it prone to be lost when injured by high velocity fragments. First, the malar bone is superficially located, acting as it does to protect the eye from trauma directed at it from below and the side. Because of its superficial location this bone is the natural recipient of much of the trauma directed at the face and the side of the head. Secondly, there is the actual osseous structure to be considered. The

From the Surgical Service of the Veterans Hospital. The opinions and conclusions expressed in this article are those of the author and do not necessarily reflect the policies of the Medical Department of the Veterans Administration.

malar bone itself is dense cancellous bone, strong and seldom fractured. Its attachments, on the other hand, are relatively flimsy. The zygomaticofrontal suture where the bone attaches to the supraorbital ridge is notoriously prone to separation, and the fragile zygomatic arch posteriorly can hardly be expected to serve as an emergency source of strength. The strongest of the malar attachments is medial to the zygomatic process of the maxilla. This attachment is also weakened by the presence of the antrum, which extends for a variable distance into the process, and by the infraorbital foramen which weakens the infraorbital margin. With these facts in mind, it is understandable that a severe force which lacerates the skin in the region of the cheek bone will also tend to dislodge the malar bone from its attachments. If, in addition, the bone is energized by contact, direct or indirect, with the traumatizing force, its loss is almost assured.

It has recently been my privilege to care for a veteran who had received a wound of the face resulting in the loss of the malar bone. This case illustrates the serious disfigurement secondary to the loss of the malar eminence and the inadequacy of cartilage and dermal implants to supply a permanent correction of the deformity. The reason for failure of these substances as prosthetic material in this case were as follows:

1. The implant had become dislodged from its original position.

2. The very nature of a cartilage graft makes accurate modeling extremely difficult.

3. Because of absorption there was secondary cicatricial contracture.

In exploring the possibilities of preparing a new prosthesis for this man, cartilage and bone were dropped from consideration because of the difficulties described. For facial reconstruction an unusually accurate prosthesis is desirable, and it was not felt that a sufficiently accurate technic was possible with either bone or cartilage. After a review of the various substances which could be used in a permanent buried prosthesis for this type of case, it was decided that the following properties were desirable:

1. The material must be nonirritating to the tissues so that it will be well tolerated and not subject to later extrusion.

2. It must be strong so that accidental injury will not fracture it.

3. It must be susceptible to firm anchorage to bony prominences so that the possibility of future dislocation will be minimal.

4. It must be versatile enough to meet with the specific indications of the individual case. In other words, it must be workable enough to permit the fashioning of a "tailor-made" appliance.

5. A technic must be possible which is at once simple and effective.

With these criteria in mind, acrylic, tantalum and vitallium® seemed to offer the most promise. Tantalum was disregarded because of its

malleability, and acrylic was felt to be too susceptible to fracture. Furthermore, both depended on a rather complicated technical process for production. Vitallium® seemed to satisfy the requirements most fully. It is practically nonirritating and extremely strong and can be wired or screwed to bone. A technic was developed which is accurate to an extreme and so simple that it can readily be used wherever the services of a modern dental laboratory are available. Finally, the use of vitallium® as a tissue substitute has been well established by long experimental and clinical experience.[1] The technic employed in treatment is contained in the following analysis.

H. S., a 32 year old white man, a World War II veteran, was wounded in action near St. Lo, France, on July 30, 1944. He was struck in the left side of the face by fragments of an 88 mm. shell. He also sustained a minor wound in the right antecubital region. He was treated and evacuated through channels, arriving at a General Hospital in the United States on Nov. 21, 1944. The history on his admission to the hospital, as carried on the records, was as follows: "Wounded in action by high explosive shell fragments, sustaining a severe avulsing injury to the left side of the face, involving damage to the left temporal bone and squamous and malar processes; compound, comminuted fracture of the frontal bone; complete avulsion of the left zygomatic process; compound, comminuted fracture of the left maxilla, and complete avulsion and penetrating wound of the left eye, resulting in surgical enucleation, on Sept. 19, 1944." While at this hospital he had eleven operations on his face, as follows: (1) Jan. 30, 1945, excision of the scar on the left side of the face and primary closure, local anesthesia; (2) April 20, repair of the deformity of the lower left eyelid with excision of scar tissue, local anesthesia; (3) May 18, excision of cicatrix, local anesthesia; (4) June 8, excision of the scar on the left side of the face, local anesthesia; (5) Aug. 24, excision of the scar on the left cheek, local anesthesia; (6) Oct. 9, plastic repair of the left outer canthus, local anesthesia; (7) Nov. 28, dermal graft on the left upper eyelid, local anesthesia; (8) Jan. 14, 1946, plastic repair of the scar on the left temple, local anesthesia; (9) April 8, dermal graft on the left cheek, general anesthesia; (10) May 10, repair of the inner canthus of the left eye, local anesthesia, and (11) May 27, fascial sling to the left lower eyelid, general anesthesia. During one of these procedures a piece of cartilage (apparently preserved) was introduced to supply a malar eminence. The record of this

1. Campbell, E.; Meierawsky, A., and Hyde, G.: Comparative Determinations of Cytotoxicity of Certain Metals in Fibroblast Culture, Ann. Surg. **114**:472-479 (Sept.) 1941. Doherty, W. B.: Orbital Implants with Special Reference to Vitallium, Arch. Ophth. **25**:637-642 (April) 1941. Girdousky, J., and Newman, H. F.: Vitallium Testicular Implant, Am. J. Surg. **53**: 514 (Sept.) 1941. Kimball, G. H., and Drummond, N. R.: Vitallium for Nasal Skeleton Support, J. Oklahoma M. A. **34**: 9-12 (Jan.) 1941. MacKenzie, C. M.; Sharpless, D. H., and Millard, P.: Vitallium Implants: Tissue Reactions, Northwest Med. **44**: 277-283 (Sept.) 1945. Venable, C. S., and Stuck, W. G.: Clinical Uses of Vitallium, Ann. Surg. **117**: 772-782 (May) 1943. Winter, L.; Lifton, J. C., and McQuillan, A. S.: Vitallium Mandibular Prosthesis Imbedment as Integral Part of Operation for Removal of Adamantinoma, Am. J. Surg. **69**: 318-324 (Sept.) 1945.

procedure, however, had apparently been lost. After these operations he was discharged as having had the maximum benefit of hospitalization and separated from the service.

After about a year, however, he became dissatisfied with the cosmetic result and applied for admission to the Lincoln Veterans Hospital. He was admitted on June 11, 1947, ambulant and in good general health. There was, however, a ghastly deformity of the left side of his face, which on cursory examination appeared to be due to a saucerization of the left temporomalar region and a displacement of the left orbit laterally and downward (fig. 1).

A general physical examination on his admittance showed no abnormalities except for the facial deformity. A detailed examination of the face revealed the

Fig. 1.—Preoperative appearance of patient illustrating the deformity described in the text.

following: (1) a post-traumatic and postoperative scar which was poorly healed, atrophic and 1.5 cm. in its widest portion; (2) saucerization of the left temporomalar region; (3) absence of the left globus oculi, with a prosthetic replacement; (4) downward and lateral displacement of the left orbit due to loss of bony support; (5) pronounced drooping of the left outer canthus due to cicatricial contracture; (6) peripheral paralysis of the middle and upper branch of the left facial nerve resulting from trauma; (7) widening of the left palpebral fissure due to the combined effects of paralysis of the lower lid and cicatricial contractures, and (8) the presence of a firm, linear substance in the left cheek lying anterior to the stump of the zygomatic process. This was assumed to be the previously inserted piece of cartilage.

Roentgen examinations revealed the following pertinent facts (fig. 2): (1) absence of the left malar bone; (2) absence of the superior, anterior and lateral wall of the left antrum, including the zygomatic process of the maxilla; (3) partial loss of the left temporal bone, and (4) several small metallic foreign bodies in the left side of the face.

Since the patient's general health was good and a year had passed after his last operation, it was felt that the time was propitious for additional reconstructive surgical procedures. The fact that the zygomatic process of the temporal bone, as well as fragments of the superior and inferior orbital ridges, was preserved suggested the possibility of anchoring a prosthetic appliance to these three bony prominences. The total problem of reconstruction was somewhat complex, but the aims could be summarized as follows:

1. Improvement of the scar.

2. Correction of the saucerization of the temporomalar region by the surgical insertion of a buried prothesis.

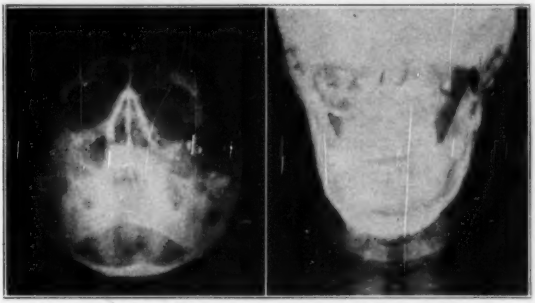

Fig. 2.—Preoperative roentgenograms showing loss of the left malar bone and associated changes.

3. Elevation of the orbit, especially of the outer canthus.

4. Support of the ptotic lower eyelid to narrow the palpebral fissure.

5. Removal of the cartilage graft which had become displaced and was now lying vertically in the cheek.

It was felt that this work could probably be done in two or three stages: first, a major procedure in which the scar would be corrected, the cartilage removed and the prothesis inserted, and, later, a minor procedure correcting the depressed outer canthus. Finally, a new ocular prosthesis would probably be needed because of postoperative changes in the orbital cavity.

The first step was to construct a prosthesis to replace the lost malar bone. A plaster cast of the face was prepared. An accurate prosthesis was fashioned out of dental stent so as to correct the deformity on the cast. The model prosthesis was then "fitted" to the patient's face and necessary alterations were made, after which the model was sent to a dental laboratory, where it was cast in vitallium.® The finished vitallium® prosthesis was fitted to the face to make certain it had not become distorted in preparation (fig. 3).

Fig. 3.—Finished prosthesis as it appeared when applied to plaster cast of patient's face.

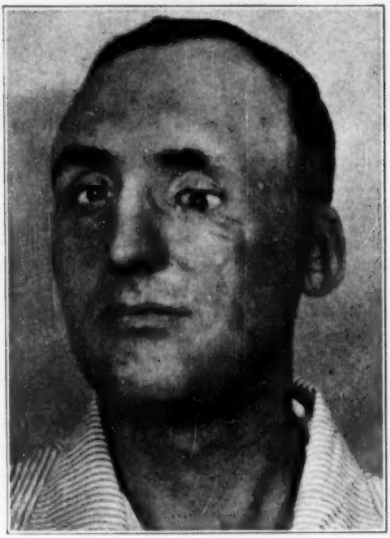

Fig. 4.—Postoperative appearance following insertion of prosthesis and revision of scar. Note the replacement of the previous malar depression by a normal contour.

After the prosthesis was obtained the patient was operated on. Local anesthesia produced with procaine hydrochloride and epinephrine hydrochloride was used. The poorly healed scar was circumcised and deepithelized. It was permitted to remain in situ although the lower end was reflected upward to fill in, to some

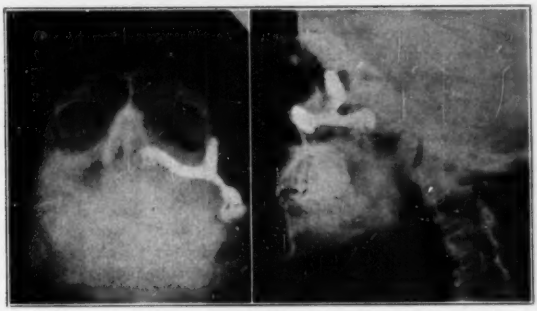

Fig. 5.—Postoperative roentgenograms showing prosthesis in place and restoration of bony contours.

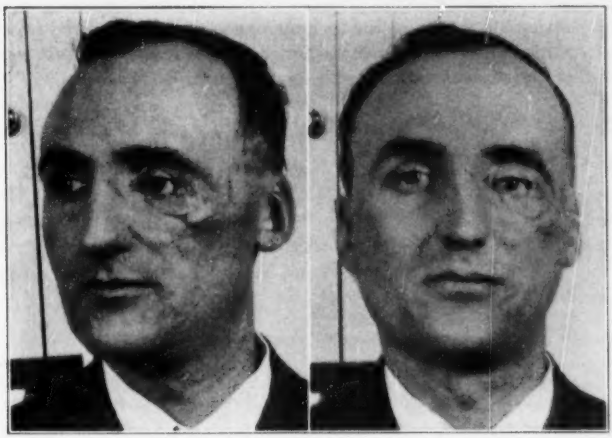

Fig. 6.—Final cosmetic result. The picture was taken immediately after removal of sutures made in the revision of the lower lid. The scar is still red and prominent but can be expected to fade. Note the restoration of the left malar prominence and the replacement of the left orbit to a more nearly normal position.

extent, the temporal defect. The ends of the superior orbital ridge, the inferior orbital margin and the zygomatic process of the temporal bone were identified and exposed. Small holes were then drilled through these bony prominences,

wires were passed through them and the vitallium® prosthesis was securely wired into position. Finally, the displaced and partially absorbed cartilage was removed and a plastic closure was achieved.

The wound healed satisfactorily and with a gratifying cosmetic result. Approximately eight weeks later a second operation was planned. At this time the original scar was well healed. The skin was freely movable over the prosthesis, and there was no evidence of reaction. Correction of the orbital deformity was planned for this operation. This was done by means of a modified Z-plasty, with mobilization of the lateral half of the orbit and elevation of the outer canthal ligament. Healing again was completely satisfactory, with a good result. However, with the change in the shape of the orbit the prosthetic eye was now rotated so that the pupil was directed at the tip of the nose (fig. 4). A new ocular prosthesis was, therefore, recommended.

After the new ocular prosthesis was obtained a final plastic procedure was done. At this time there was a revision of the skin of the left lower eyelid, and the lid was supported by means of a sling, which narrowed the palpebral fissure. The sling was fashioned out of no. 20 cotton thread and supported the inferior tarsal plate by being looped about the internal canthal ligament. A good result was obtained, and the patient was discharged as having received maximum hospital benefit (figs. 5 and 6).

SUMMARY

The mechanism involved in injuries producing loss of the malar bone is discussed. The problems involved in the plastic reconstruction are briefly reviewed. Vitallium® is suggested as a material peculiarly adaptable for this purpose. The method for the preparation of the prosthesis is outlined, and a representative case is presented in detail.

PERIPHERAL ARTERIAL EMBOLISM

With Particular Reference to an Evaluation of Conservative Treatment

WILLIAM DeWITT ANDRUS, M.D.
NEW YORK

EMBOLISM of the arteries to the limbs is a dramatic event which varies in its consequences with a number of factors. Thus, the lodgment of an embolus in some of these arteries such as the anterior or posterior tibial vessel in the leg or the radial, ulnar or occasionally even the brachial or axillary vessels in the arm may be attended by no serious symptoms or results beyond transient pain and weakness. In general, as this would imply, the sudden embolism of the larger vessels of the legs is of graver significance, but even in such instances the prognosis may vary greatly and depends on a number of circumstances aside from the mere local vascular occlusion. For example, the outlook is much better in the younger patient and in persons with rheumatic heart disease than in those in whom the cardiac lesion is of arteriosclerotic origin. Not only is this true of the patient who is treated conservatively but it profoundly influences the results following embolectomy.

METHODS OF TREATMENT

Since this operation was first attempted by Ssabanejeff,[1] in 1895, and Labey [2] in 1911 and Key [3] in 1922 performed it successfully, it has been widely applied and, indeed, in some quarters came to be considered as the only form of treatment despite the high mortality which followed its use. Extensive surveys of reported results are to be found in the review of McClure and Harkins [4] and the monograph of Haimovici.[5]

From the Department of Surgery, New York Hospital-Cornell University Medical College.

1. Ssabanejeff: On Question of Blood Vessel Suture, Russk. khir. Arch. **11**: 625, 1895.

2. Labey, cited by Mosny, M., and Dumont, N. J.: Embolie fémorale au cours d'um rétrécissement mitral pur: Artériotomine guérison, Bull. Acad. méd. **66**:358, 1911.

3. Key, E.: Ueber Embolectomy als Behandlungsmethode bei embolischen Zirculationsstörungen der Extremitäten, Acta chir. Scandinav. **54**:339, 1922.

4. McClure, R. D., and Harkins, H. N.: Recent Advances in Treatment of Peripheral Arterial Embolism, Surgery **14**:747, 1943.

5. Haimovici, H.: Les embolies artérielles des membres, Paris, Masson & Cie, 1937.

As more has been learned, however, concerning the pathologic and abnormal physiologic changes involved and experience has been gained in the conservative management of patients, attempts are now being made to evaluate the various methods of treatment and to select the types of cases in which they should be applied. Thus, Warren and Linton [6] reported 110 cases of arterial emboli involving the extremities handled in various ways. In 38 of these, for example, no treatment of the local condition was employed because the patients "were admitted to the hospital so late that the fate of the limb had already been decided by the time they were first observed." In this group 21 (more than 55 per cent) of the involved limbs were saved, but the authors felt that the figure is somewhat deceptive so far as it is an indication of what may be expected in general since a disproportionately large number of patients with emboli to the vessels of the upper extremity, for whom the prognosis is known to be more favorable, were included. Gangrene developed in 17, or 70.8 per cent, of 24 instances of embolism involving the lower extremities in which no treatment was instituted. In Warren and Linton's series 55 per cent of the limbs were saved in the cases in which no treatment was employed, while with conservative therapy the percentage rose to 65.8 per cent. When operation was added, the results were still better, the percentage of limbs saved rising to 85.7 per cent. These figures are of interest since they indicate that even in the absence of therapeutic measures recovery without gangrene is to be expected in a certain, though relatively low, percentage of cases and suggest that factors other than those which are ordinarily affected by the therapeutic measures at hand are influential in determining the outcome. It becomes important, therefore, to appreciate the chain of deleterious effects in an extremity following the lodgment of an embolus in its main vessel and to consider the means now available for their relief.

When an embolus has lodged in an artery several other factors may influence its ultimate effect on the limb, the survival of which depends on the maintenance of at least the minimal circulation to support viability in the portion distal to the point of obstruction. Thus, the spasm of the vessels of the limb and propagation of a clot distal to the embolus may seriously compromise the other channels on which the establishment of adequate collateral circulation depends.

The association of spasm of peripheral vessels with sudden obstruction at a proximal point has long been recognized and in connection with embolism was described by Siefert [7] and has been commented on

6. Warren, R., and Linton, R. R.: The Treatment of Arterial Embolism, New England J. Med. **238**:421, 1948.

7. Siefert, E.: Die Deutung des Schmerzes bei der arteriellen Embolie, Deutsche Ztschr. f. Chir. **232**:187, 1931.

by most authors who have performed embolectomy. More recently Laufman, Martin and Tuell,[8] after a study of sudden vascular obstruction in the mesentery of the dog, reported that in arterial occlusion there is marked arterial and venous spasm. When the occlusion is released, gross visible reactive hyperemia occurs, but during this state the precapillary artery remains in spasm. The degree of narrowing may be severe and involves both the large and small vessels, the latter being practically blocked, and if not relieved this spasm may not only itself obstruct the circulation but may become associated with secondary thrombosis. By analogy, similar changes may be thought of as occurring in the vessels of the limb distal to an embolus lodged in its major artery, and most important in this connection is the finding of Laufman and his associates that even when the obstruction is released the arteries do not regain their original caliber for some time.

It is evident, therefore, that in all cases of embolism involving the extremities the most efficient measures available should be employed to relieve the associated spasm of the peripheral vessels. While various methods, including administration of drugs such as papaverine and, more recently, tetraethylammonium, mechanical measures such as alternate positive and negative pressure and procedures aimed at interrupting the sympathetic pathways (paravertebral block and sympathectomy), have been employed in the past, the direct approach illustrated by block and sympathectomy is certainly the most efficacious and should be instituted whether or not embolectomy has been performed.

The slowed circulation in the arterial tree distal to the point of occlusion and involved in spasm is favorable for the propagation of thrombus which may be of such an extent that it blocks potential or actual collateral vessels and thus further jeopardizes the integrity of the limb. Such thrombosis may also occur to a certain extent proximally but usually involves only the cul-de-sac between the embolus and the first proximal arterial branch.

Prevention of such thrombus formation not only after the embolus has once lodged but also for a considerable period after embolectomy is an important feature of the therapy and is today best carried out by the early administration of heparin and the subsequent reliance on dicumarol® (3,3′-methylenebis [4-hydroxycoumarin]) with careful study of the clotting time and prothrombin activity.

The cardiac status of the patient has received great attention as it relates to the origin of the embolus and the general condition of the patient, but it can be shown also that it has a crucial bearing on the

8. Laufman, H.; Martin, W. B., and Tuell, S. W.: The Pattern of Vasospasm Following Acute Arterial and Venous Occlusions, Surg., Gynec. & Obst. **87**:641, 1948.

survival of the extremity in which an embolus has lodged. As indicated previously, spasm or the extension of thrombosis may interfere with the development of collateral circulation, but even with free channels a certain "head of pressure" is required to provide blood flow by the collateral routes. If cardiac decompensation is present, not only is the driving force of this organ diminished but the venous pressure is increased, with still further interference with the blood flow. All these factors must be taken into consideration when the measures to be employed in handling a given patient with embolism are being outlined.

The conservative measures now available for the treatment of peripheral arterial embolism have been developed and applied during the past fifteen years. Treatment with intermittent positive and negative pressure was developed by Herrmann and Reid,[9] and Collens and Wilensky [10] reported their experience with intermittent venous occlusion in 1937. The possibility of relieving associated vascular spasm by means of drugs or surgical procedures directed at the sympathetic nerve supply of the extremity has been recognized for many years, and this now constitutes an important part of conservative therapy as well as an ancillary method when embolectomy is employed. Likewise, since heparin and dicumarol® have become available in purified form they have come to occupy a prominent place in both the conservative and operative methods of handling cases.

While embolectomy has been performed in cases of saddle or iliac embolism when the condition would permit, it has otherwise been the general policy in the 73 instances of peripheral arterial embolism in the ward services of the New York Hospital to treat patients with embolism of the peripheral arteries of the limbs by conservative measures, and over the fifteen year period covered by this study all the currently recognized methods have been employed. Embolectomy was excluded in these cases even though the majority of patients were seen within a few hours of the onset of symptoms because it was felt that the results being obtained by other means were better in general than those reported after this operation as measured on the basis of the mortality rate and the occurrence of gangrene. The present study was undertaken, however, with the idea of reevaluating such methods in the light of more recent experience and of determining whether withholding of operation is correct as a general policy or whether it might be applied in some cases with even better results than could be attained by conservative meas-

9. Herrmann, L. G., and Reid, M. R.: Passive Vascular Exercises: Treatment of Peripheral Obliterative Arterial Diseases by Rhythmic Alternation of Environmental Pressure, Arch. Surg. **29**:697 (Nov.) 1934.

10. Collens, W. S., and Wilensky, N. D.: Intermittent Venous Occlusion in Treatment of Peripheral Vascular Disease: Experience with One Hundred and Twenty-Four Cases, J. A. M. A. **109**:2125 (Dec. 25) 1937.

ures alone. The cases of embolectomy observed by my colleagues and me are relatively few in number, and while the results have been roughly comparable to those published by others, the series is not sufficiently large to permit significant conclusions to be drawn.

CASE MATERIAL

We have had 15 cases of embolus of the saddle type or involving one or both iliac arteries, and, like that of others, our experience with these confirms their serious nature. Of the 10 instances of saddle embolism 6 occurred so late in the course of serious heart failure as to make any form of treatment ineffective, and in another patient the embolism occurred in the late months of pregnancy, this being a 38 year old woman who had rheumatic heart disease and who was in decompensation at the time. All the 7 patients died. Three others survived, though in each gangrene of one leg developed, which required midthigh amputation. Embolectomy was performed in 1 patient who survived and in 1 who died (in both instances via a bilateral iliofemoral approach).

There were 5 patients with iliac embolism, 4 of whom died. In 2 instances the embolism was a terminal event in the course of hypertensive cardiovascular disease, and one occurred twenty-four hours before the patient entered the hospital. Two other patients succumbed to subacute bacterial endocarditis superimposed on rheumatic heart disease in the period before adequate antimicrobial therapy was available, but it is interesting to note that both lived long enough after the occurrence of the embolism for the ultimate effect on the circulation to be demonstrated; gangrene developed in 1 and necessitated amputation and the other lived for five days without evidence of critical circulatory impairment in the limb.

Thus, of these 15 patients, 11 died; gangrene developed in 3 of the survivors, in 1 after embolectomy, and 1 of those who subsequently died lived long enough to indicate that gangrene would not ensue.

Aside from these, there were 57 instances of embolus in the arteries of the limbs in 50 patients. In 23 instances the popliteal artery was involved, in 20 the femoral, in 10 the brachial, in 3 the axillary and in 1 the posterior tibial artery. All were treated by conservative measures, and in none of this group was embolectomy performed. Sixteen patients died, and in 5 of these the embolus occurred so late in the course of cardiac disease that any form of treatment was probably rendered useless, but they are included in the series since they contribute to the picture of the over-all results. Two of the group died of subacute bacterial endocarditis but lived from five to thirty days after the embo-

lism without the development of gangrene. One died of pulmonary embolism, while in 2 coronary occlusion was the immediate cause of death.

Among the 20 patients with embolism of the femoral artery 14 survived and 6 died. There were 2 instances of gangrene in those who survived. In 23 cases of popliteal embolus there were 16 survivals, 7 deaths and 4 instances of gangrene. In 10 cases of brachial emboli there were 2 deaths, both of which occurred shortly after the embolism. There were no instances of gangrene. Three axillary emboli were encountered, 1 patient dying with gangrene, and there was a single instance of obstruction of the posterior tibial artery which was unassociated with gangrene.

In the 57 cases of emboli involving the femoral, popliteal, tibial, axillary and brachial arteries there were 16 deaths, a mortality rate of 32 per cent (28 per cent of the emboli). The 44 emboli in the lower limbs were associated with a 30 per cent mortality, while the rate when the upper extremity was involved was 23 per cent. The fatalities occurred in 12 instances in connection with arteriosclerotic cardiovascular disease, while in 4 the cardiac lesion was on a rheumatic basis, in 3 of these associated with subacute bacterial endocarditis at a time before modern antimicrobial therapy was available. The average age in the former was 61.3, while for the rheumatic patients it was 42.5. The average age in the fatal cases in the series was 56 years, while those who survived averaged 44.1 years.

In this series there were 23 emboli associated with arteriosclerotic heart disease, 31 associated with rheumatic heart disease and 1 each associated with hyperthyroidism, typhus and Cooley's anemia. The mortality rate when the embolism was on an arteriosclerotic basis was 52.2 per cent, as contrasted with approximately 13 per cent when the embolus occurred in a patient with rheumatic heart disease.

There were but 7 instances of gangrene in the entire 57 cases of emboli involving the limb vessels, an incidence of 12.3 per cent, and in 2 of these the embolus had occurred some time before and gangrene was already present when the patient was admitted to the hospital. In 4 the embolus lodged in the popliteal artery, in 2 in the femoral and in 1 in the axillary artery. These occurred in 1 patient 46 years of age with coronary occlusion and mural thrombus; in 2 patients with rheumatic heart disease aged 29 and 47 respectively, the first with associated subacute bacterial endocarditis; in 1 patient 45 years of age with hyperthyroidism and auricular fibrillation, and in 3 persons, 43, 54 and 67 years of age respectively, with arteriosclerotic heart disease. The striking feature in these cases was of course the relative youth of the patients, since their average age (47.3 years) is well below that of the series as a whole. Their number is too small to draw conclusions, but

in seeking an explanation one finds that in 5 cardiac decompensation was present at the time the embolism occurred and for a period thereafter. This, we have come to feel, is a critical factor in the determination of whether or not gangrene will ensue, and it seems likely that it was of importance in the development of gangrene in these cases.

COMMENT

Almost all patients with embolism of a major peripheral vessel are seriously if not critically ill, and the nicest judgment is required to select that method of treatment which will give the best result in regard to the survival of the patient, the saving of his extremity and its preservation as a useful limb. In general, it may be said that the patient with arteriosclerotic heart disease has a much poorer prognosis because of the severity of the cardiac lesion itself and the lack of cardiac reserve, in contrast to the patient with uncomplicated rheumatic heart disease, who, despite the presence of fibrillation and the development of a clot in an auricular appendage, often has a fairly good cardiac status. In addition, the peripheral arterial system in the rheumatic patient is ordinarily normal because of his lower age and the fact that the disease is usually limited to the heart itself. The situation has been obviously different in the past, however, in the case of the patient with rheumatic heart disease complicated by bacterial endocarditis, but since the demonstration in recent years of the efficacy of antimicrobial therapy in the control of subacute bacterial endocarditis these cases too present a somewhat better prognosis. In the elderly patient with arteriosclerotic heart disease, however, the process which has affected the myocardial vessels usually represents only a part of a widespread disease and has brought about a serious narrowing of the peripheral vessels as well.

While in this study the results of conservative measures have been judged on the basis of their effect on mortality and the preservation of limbs without gangrene, it must be admitted that almost all patients who had suffered embolism of the leg vessels and survived without gangrene had some impairment of function of the limb. Their disability varied from mild weakness and signs of circulatory deficiency such as intermittent claudication to severe weakness and neurologic disturbances such as numbness, tingling or spontaneous pain in the involved extremity. In the elderly arteriosclerotic patient this, while not ideal, presented a tolerable condition, but in a number of younger patients it constituted a serious handicap to an active life. Embolism of the upper extremity usually cleared without any considerable disability.

SUMMARY AND CONCLUSIONS

After reviewing these results and considering the factors discussed, we have reached the following conclusions:

1. Saddle embolus and iliac embolism are extremely serious complications, and, tending as they do to occur in patients in otherwise critical condition, are associated with an extremely high mortality and a high incidence of gangrene with any form of treatment. For patients who will tolerate the operation embolectomy is indicated, combined with the prompt employment of ancillary methods.

2. While in this series the results of conservative therapy in cases of emboli involving the femoral and popliteal arteries as well as the vessels of the upper extremity have been good, being followed by as low a mortality rate as that in most reported series after embolectomy, and a lower incidence of gangrene, it is believed that they could be improved in some instances.

3. The attack on the clinical syndrome in the patient with peripheral arterial embolus should include various measures which fall into three general categories:

A. Measures aimed at the relief of the spasm in the vessels of the extremity should be adopted immediately. Of those available, direct attack on the sympathetic nerve supply to the involved part is to be preferred above all others and may be carried out temporarily by procaine hydrochloride block. Sympathectomy should be resorted to in most instances. Papaverine may be useful, but its effects are apt to be transient and irregular.

B. Anticoagulant therapy with heparin and dicumarol* should be instituted in all cases at once except those in which embolectomy is planned; in these it may be withheld until the close of the operation. It may also be employed for a longer period as an aid in preventing further clot formation in the auricle in the presence of fibrillation, but areas such as the sites of peptic ulcer or polyps, from which serious hemorrhage may occur, should be excluded.

C. Embolectomy has been reserved in the past for patients with saddle or iliac embolism whose general condition would permit it, and we have employed it in this series because of the high mortality and incidence of gangrene without the operation.

We feel, on the basis of our experience and despite the relatively low incidence of gangrene in embolism of other vessels when conservative measures were employed, that the results, particularly in the younger age group, could be improved if embolectomy were added. Thus, we favor its use in patients seen within twelve hours with femoral or popliteal embolism secondary to old rheumatic heart disease and auricular fibrillation in the absence of cardiac decompensation because of the chance of restoring their peripheral circulation to a condition closely approximating the normal by removing the obstruction and using anticoagulants and interruption of sympathetic pathways as ancillary meth-

ods. By these means we believe that the early results would be improved and much of the late disability avoided. In view of the success to be expected from modern antimicrobial therapy in subacute bacterial endocarditis complicating rheumatic heart disease, we favor embolectomy in cases of embolism associated with this condition on the same basis as we favor it for embolism associated with rheumatic heart disease alone. We still feel that for the elderly patient with generalized arteriosclerosis and arteriosclerotic heart disease the chances of improving the situation by adding embolectomy to the conservative measures now available are so small as to contraindicate its use except in rare cases. Further study of the influence of various factors in the prognosis of peripheral arterial embolism is desirable.

RESECTIONS OF THE LUNG IN THE TREATMENT OF PULMONARY TUBERCULOSIS

O. C. BRANTIGAN, M.D.
AND
H. L. RIGDON, M.D.
BALTIMORE

IN CASES of pulmonary tuberculosis there is no practical method of classifying the types of disease before treatment is begun. After treatment has been carried out, so many variable factors develop that there are no definite criteria for evaluation of the results. When it is reported that the sputum is negative for tubercle bacilli, it must be indicated whether it is negative on direct smear, on concentration, on culture or on guinea pig inoculation and, finally, whether the secretions were obtained by bronchoscopic aspiration or by expectoration. Since there is no working classification of pulmonary tuberculosis before treatment is started and since the evaluation of treatment is so indefinite, there will always be a difference of opinion concerning the proper method of treatment for the individual patient.

The treatment of pulmonary tuberculosis can be divided into three major categories: the prophylactic, the medical and the surgical treatments. The prophylactic treatment depends on the elimination of contacts or on the establishment of immunity by the use of vaccination.[1] If the prophylactic treatment fails, medical treatment becomes necessary. The latter consists in bed rest, the proper dietary regimen including vitamins and minerals, adequate fresh air, a happy environment, specific chemotherapy or the use of antibiotics when indicated and the medical relief of symptoms as they occur. Such treatment can be given anywhere but usually is carried out to the best advantage in a sanatorium. It is often spoken of as sanatorium treatment. Sanatorium treatment is the foundation on which all treatment of tuberculosis is based. Surgical treatment should be considered supplementary to sanatorium treatment but is never a definite treatment in itself. However, it should also be pointed out that most patients in whom pulmonary tuberculosis develops recover without becoming sick with the infection; if the patient does

From the Department of Surgery, University of Maryland School of Medicine.

1. Levine, M. I., and Sockett, M. F.: Results of BCG Immunization in New York City, Am. Rev. Tuberc. **53**:517, 1946. Aronson, J. D., and Palmer, C. E.: Experience with BCG Vaccine in the Control of Tuberculosis Among North American Indians, Pub. Health Rep. **61**:802, 1946.

become sick, in the overwhelming majority of cases the disease is arrested as the result of medical treatment. When the response to medical treatment is delayed in its progress or when such treatment fails to cure the patient, surgical intervention is resorted to as part of a comprehensive plan.

SURGICAL TREATMENT

Surgical treatment can be divided into three classifications: collapse therapy; drainage of cavities, either open or closed, and pulmonary resections, including segmental resections, lobectomy or pneumonectomy. It is becoming increasingly evident that the collapse therapy is poor treatment when one of the following conditions is present: a giant cavity, a large tension cavity, a destroyed lung,[2] fibrotic bronchial stenosis or bronchiectasis. It is also noteworthy that patients who have a pulmonary tuberculoma should not be treated by collapse therapy. With the exclusion of these types of lesions there remains a large group of patients with pulmonary disease whose condition will be benefited definitely or arrested by collapse therapy. Patients with a tension cavity may be candidates for closed drainage. Those with a persistent cavity after thoracoplasty may be suitable candidates for drainage of their cavity by either the open or the closed method.

Resection of the lung in the treatment of pulmonary tuberculosis is indicated for those patients with unilateral disease who do poorly with medical treatment and for whom collapse therapy is not indicated because of a giant cavity, large tension cavity, destroyed lung, fibrotic bronchial stenosis, tuberculous bronchiectasis or tuberculoma. It is also indicated for those patients who continue to have active disease in spite of adequate collapse therapy. When adequate collapse therapy, particularly thoracoplasty, has failed, there seems to be little that can be offered in the way of treatment, except excision of the diseased area. However, resection may fail to cure the patient because tuberculosis of the lung is not always well localized. Removal of the major focus does little toward bringing the minor foci under control.[3] Certainly it does not assure the healing of the minor foci.

Progress in anesthesia, a better understanding of shock and the method of treatment and improvement in surgical technic have all combined to make pulmonary resection an increasingly safer operation. The effect of streptomycin on pulmonary tuberculosis has added tremendously to the safety of pulmonary resection as a method of treatment.

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2. Overholt, R. H.; Wilson, N. J.; Szypulski, J. T., and Langer, L.: Pulmonary Resection in the Treatment of Pulmonary Tuberculosis, Am. Rev. Tuberc. **55**:198, 1947.

3. Sweet, R. H.: Lobectomy and Pneumonectomy in the Treatment of Pulmonary Tuberculosis, J. Thoracic Surg. **15**:373, 1946.

Through the efforts of many workers, such as Overholt,[4] Bailey,[5] Sweet,[3] and Brewer [6] and others, resection has become an established method of treatment. Clearly defined indications for pulmonary resection in the treatment of tuberculosis of the lungs would be extremely helpful. The following indications have served as a guide for the cases reported in this paper.

I. Known pulmonary tuberculosis (fig. 1 through fig. 7).
   (*a*) Elective resections (fig. 1).
   (*b*) Nonelective resections (fig. 2 through fig. 7).
      1. Failure of collapse therapy (fig. 2 through fig. 4).
      2. Bronchial disease (giant cavity, large tension cavity, destroyed lung, fibrotic bronchial stenosis, tuberculous bronchiectasis [figs. 5 and 6]).
      3. Tuberculoma (fig. 7).

II. Questionable diagnosis (fig. 8).
      1. Patients with active tuberculosis and negative reactions to bacteriologic tests whose roentgenograms and symptoms simulate those of another disease for which excision is indicated (fig. 8*A* and *B*).
      2. Patients who have false positive reactions to bacteriologic tests for tuberculosis but who have other pulmonary disease (fig. 8*C*).
      3. Patients who have pulmonary tuberculosis and some other pulmonary disease (fig. 8*D*).

III. Apparently arrested pulmonary tuberculosis with symptoms that are actually the result of suppuration in a distorted bronchial tree (fig. 9).

In caring for the patient with known pulmonary tuberculosis, the method of treatment chosen often is based on clinical judgment. If pulmonary resection is carried out when the patient is a candidate for medical treatment or for some type of collapse therapy, then the operation must be looked on as an elective one. Only 2 patients in the present series underwent elective resections.

Under the classification of nonelective pulmonary resections are those cases in which pulmonary tuberculosis is not arrested in spite of good medical treatment combined with efficient collapse therapy when this is indicated. Under this classification must also be placed cases of giant cavity, large tension cavity, destroyed lung, fibrotic bronchial stenosis, bronchiectasis or sizable tuberculoma, even though prolonged medical treatment or collapse therapy is not carried out before pulmonary resection of the diseased area is undertaken. Without operation it is often

4. Overholt, R. H.; Langer, L.; Szypulski, J. T., and Wilson, N. J.: Pulmonary Resection in the Treatment of Tuberculosis, J. Thoracic Surg. **15**:384, 1946.

5. Bailey, C. P.: Lung Resection for Pulmonary Tuberculosis, J. Thoracic Surg. **16**:328, 1947.

6. Brewer, L. A., III; Dolley, F. S., and Jones, W. M. G.: Indications for Pulmonary Resections for Tuberculosis Both by Lobectomy and Pneumonectomy, Dis. of Chest. **14**:491, 1948.

difficult to differentiate between tuberculoma and carcinoma of the lung. It is understood, however, that the patient must be free from disease in the contralateral lung or that roentgenographic study indicates that the disease in the contralateral lung has been healed or stable for at least one year.

Although adequate clinical and laboratory studies have been completed, a definite diagnosis cannot always be made. The group of patients with a questionable diagnosis presents an interesting surgical problem. Many of them would be denied the benefit of resection if the presence of pulmonary tuberculosis were considered a contraindication.

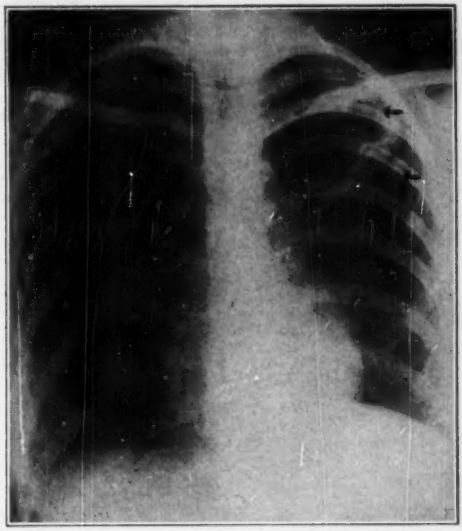

Fig. 1.—Known pulmonary tuberculosis; elective resection. Medical treatment failed to arrest the disease. Pneumothorax could not be induced. Temporary phrenic paralysis was helpful. The patient would have been a good candidate for a standard thoracoplasty.

These patients fall into three categories. Pulmonary tuberculosis may be suspected but cannot be proved bacteriologically. Occasionally a false positive reaction to a bacteriologic test for tubercle bacilli conceals the diagnosis of carcinoma or some other pulmonary disease. Rarely are pulmonary tuberculosis and carcinoma of the lung found in the same patient. The patients operated on who did not have pulmonary tuberculosis are not included in this study.

Frequently definite pulmonary symptoms will develop in a patient who has been known to have pulmonary tuberculosis for many years

and who has been apparently cured of the disease, such as a cough, expectoration, fever, malaise and loss of weight. Bacteriologic examination of these patients usually will reveal no evidence of tubercle bacilli, but since they were known to have had tuberculosis for many years it is difficult to be certain that the profuse expectoration is not masking the presence of bacilli in the sputum. If the surgeon were not willing to do

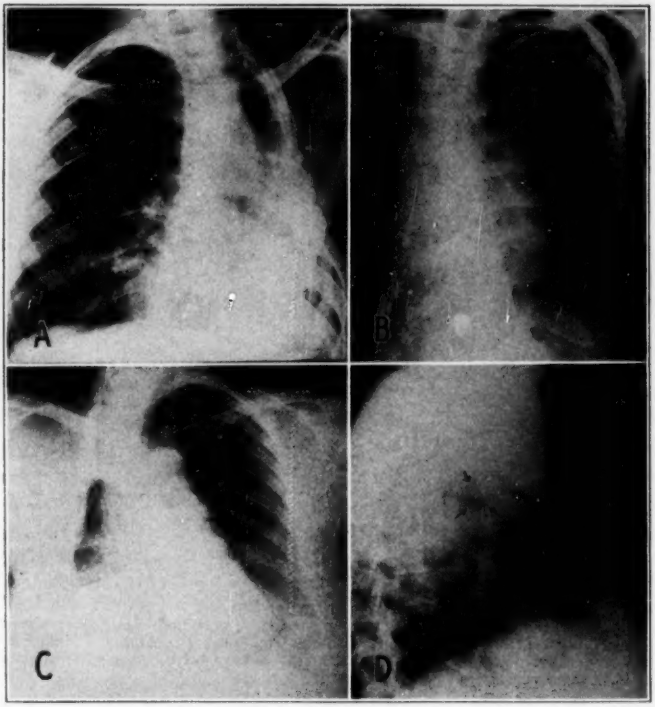

Fig. 2.—Known pulmonary tuberculosis; nonelective resection because of failure of collapse therapy. Roentgenograms after failure of thoracoplasty are shown. *A* and *B* are roentgenograms of 2 patients subjected to pneumonectomy. *C* and *D* are two views of the same patient who underwent resection of the upper lobe of the right lung.

resections for pulmonary tuberculosis, these patients would be deprived of the opportunity of being well again. There are probably more of these than is generally realized. Patients who belong in this group have not been included in the cases reported in this paper.

Fifty-one patients were subjected to fifty-two pulmonary resections in the present series dating from February 1942 to August 1948. There were thirty-nine pneumonectomies and thirteen lobectomies performed. Thirty patients were women, and 21 were men. In this group were 14 Negro patients, 5 women and 9 men. The youngest patient in the group was 21 years old, and the oldest was 48. The disease was unilateral in

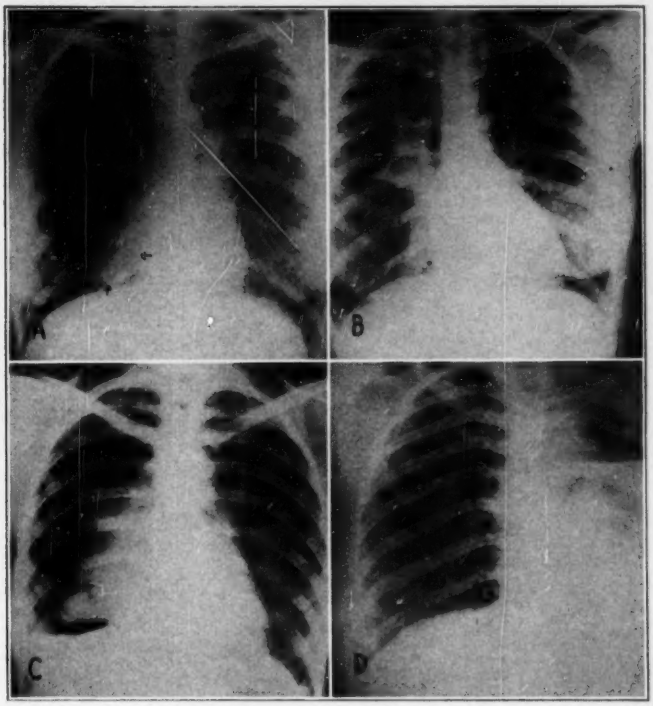

Fig. 3.—Known pulmonary tuberculosis; nonelective resection because of failure of collapse therapy. Typical roentgenograms after failure of pneumothorax are shown. *A* shows a patient who underwent resection of the lower and middle lobes of the right lung. *B*, *C* and *D* are roentgenograms of patients who were subjected to pneumonectomy.

37 patients and bilateral on roentgenographic evidence in 14. In each of the 14 patients the contralateral disease was minimal and had been stabilized for at least one year previous to pulmonary resection; all patients had a fair trial of medical treatment. Thirty-five of the patients pre-

viously had been given sanatorium care. Twenty-five had undergone unsuccessful pneumothorax. Seven of these patients had undergone closed pneumonolysis, and 1 had been subjected to open pneumonolysis. Eight of them had undergone previous thoracoplasty. In 16 patients

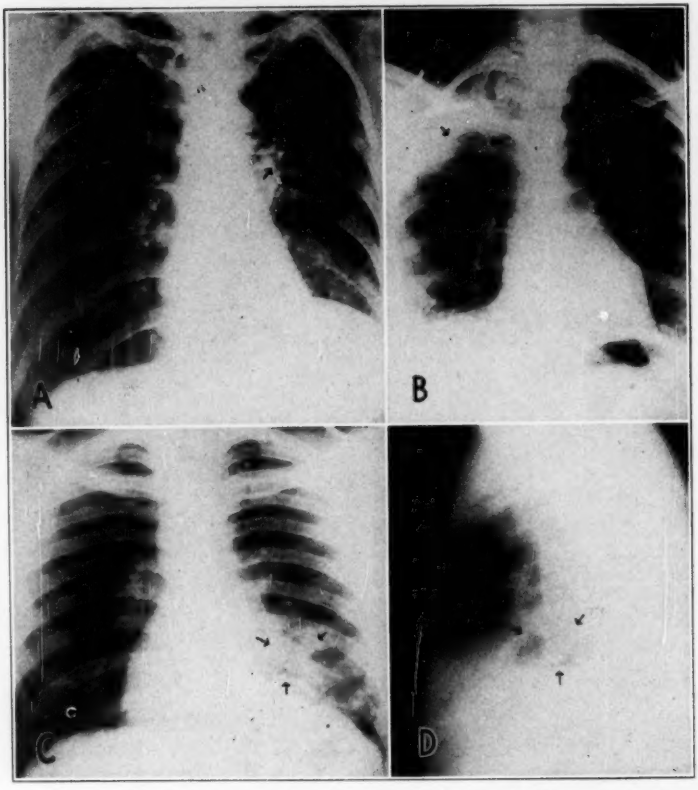

Fig. 4.—Known pulmonary tuberculosis; nonelective resection because of failure of collapse therapy. *A*, roentgenogram of a patient who had nine years of treatment including bed rest, pneumothorax, pneumonolysis, temporary phrenic paralysis and pneumoperitoneum. Finally, all collapse measures were abandoned. Thoracoplasty did not seem to be indicated. Pneumonectomy was done on the left side. *B*, unsatisfactory end result of an old extrapleural plombage with air. The cavity was merely pushed to a lower level. *C* and *D* are examples of a cavity at the base, against the mediastinum, uninfluenced by phrenicotripsy and pneumoperitoneum.

temporary phrenicotripsy had been performed, 4 of whom received pneumoperitoneum. In 1 patient the lower and middle lobes of the right

lung were removed, with a subsequent breakdown of the remaining upper lobe on the right. This was followed by thoracoplasty without cure, and finally the remaining upper lobe of the right lung was removed. Twenty of the patients had undergone no previous operation or collapse therapy.

The follow-up on these patients has been complete. However, the duration of the follow-up is, in many cases, so short that no real conclu-

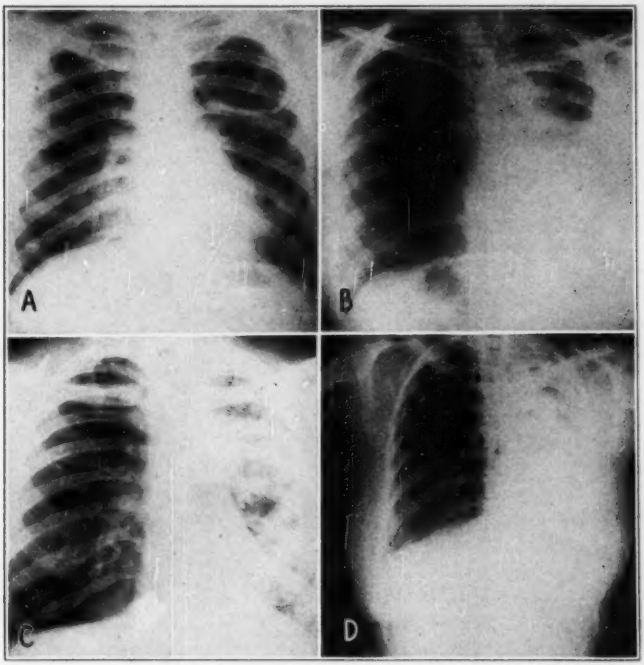

Fig. 5.—Known pulmonary tuberculosis; nonelective resection because of bronchial disease. It appears that the four roentgenograms shown are variations of the same condition, all brought on by a particular type of bronchial disease. *A*, tension cavity; *B*, giant cavity; *C*, destroyed lung; *D*, fibrotic bronchial stenosis. Patients with disease of this type respond poorly to all methods of treatment except excision.

sions can be reached so far as end results are concerned. It seems logical to divide the patients into two groups: those operated on before streptomycin was available and those operated on after streptomycin was available for protection against the postoperative spread of pulmonary tuberculosis.

Before streptomycin was available twelve pneumonectomies and eleven lobectomies were done. The early death rate for those subjected to pneumonectomy was 33.3 per cent. There were 2 late deaths; all the other patients who survived the operation are well. Of the 11 who underwent lobectomy, 1 died, and 7, or 63.6 per cent, remained well without further operation. Three, or 27.3 per cent, became sick and underwent further surgical treatment for reactivation of their disease. Two were treated by thoracoplasty; in 1 this was followed by pneumonec-

TABLE 1.—*Results of Pneumonectomy*

Before Streptomycin			After Streptomycin		
Number of patients	12		Number of patients	27	
Operative deaths	4	33.3%	Operative deaths	0	0%
Late deaths	2	16.7%	Late deaths	1	3.7%
Sick patients	0	0	Sick patients	5	18.5%
Well patients	6	50.0%	Well patients	21	77.7%

TABLE 2.—*Results of Lobectomy*

Before Streptomycin			After Streptomycin		
Number of patients	11		Number of patients	2	
Operative deaths	1	9.0%	Operative deaths	0	0
Late deaths	0	0	Late deaths	0	0
Sick patients	3	27.3%	Sick patients	0	0
Well patients	7	63.6%	Well patients	2	100%

TABLE 3.—*Mortality Rate for All Resections*

Lobectomy			
Postoperative mortality	7.0%	Late mortality	0.0%
Pneumonectomy			
Postoperative mortality	10.2%	Late mortality	7.6%
All Resections			
Postoperative mortality	9.6%	Late mortality	5.7%
Total early and late mortality			15.3%

tomy, and the other underwent phrenicotripsy and pneumoperitoneum. At the present time 3 of the group are sick, and 7 are well; there have been no late deaths among these. After streptomycin became available and could be employed as protection against the spread of disease, twenty-seven pneumonectomies were done. There were no operative deaths, but there has been 1 late death. The patient who died was discharged from the sanatorium with the diagnosis of arrested tuberculosis. The circumstances surrounding his death could not be determined, but it is likely that he died of pulmonary tuberculosis. Of this group, 21 are well and their sputum is negative for tubercle bacilli. Five of the patients are sick. Two of these are clinically well, but the sputum of 1 is positive

for tubercle bacilli on direct smear and that of the other is positive only on culture; 1 patient has active disease in the remaining lung; 1 has asthma and a positive sputum, and 1 has a positive sputum with a possible bronchopleural fistula and probably will die shortly. Since the use of streptomycin, lobectomy has been done on only 2 patients, and both are well.

The method of preoperative treatment, the operative technic and the postoperative management have all evolved slowly.[7] At present all patients receive sulfamerazine and sulfadiazine for forty-eight hours before operation in order to help protect against postoperative pneumonia. These drugs are not given after operation. All patients receive streptomycin at least two or three days before operation

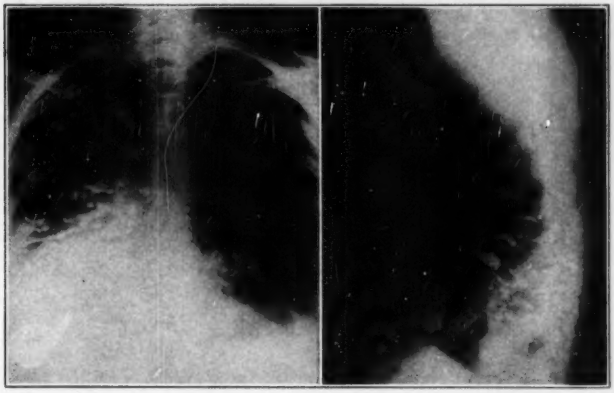

Fig. 6.—Known pulmonary tuberculosis; nonelective resection because of bronchial disease. The roentgenograms illustrate a patient with tuberculous bronchiectasis of the lower lobe.

in divided doses of 2 Gm. per day. The administration of streptomycin is continued for at least two weeks after operation. The daily dose is reduced to 1 Gm. about seven days after operation. Each patient receives at least 1 pint (500 cc.) of blood the day before operation and blood is given generously during operation and afterward as it is needed. As much as 6 pints (3,000 cc.) of blood has been administered while the patient was on the operating table. The operation is done with the patient under intratracheal anesthesia. Hs is placed in a prone position on shoulder braces and hip supports, as advocated by

7. Brantigan, O. C.: Resection of the Lung in the Treatment of Pulmonary Tuberculosis, Arch. Surg. **51**:147 (Oct.) 1945.

Overholt.[2] Contamination of the pleural cavity is avoided by extrapleural stripping of any area that is adherent to the wall of the chest. All diseased pulmonary tissue is resected, and therefore pneumonectomy is done more frequently than lobectomy. The hilar structures are individually dissected free and then amputated and controlled. The bronchial stump is always covered with living tissue from the adjacent regions. Chloroazodin (azochloramid®) in a dilution of 1 : 3,300 and sodium tetradecyl sulfate in a dilution of 1 : 500 with sulfanilamide are routinely placed in the pleural cavity, as an antiseptic solution and to reduce the postoperative exudation of fluid into the pleural cavity. After the use of this solution it is rare that the chest need be aspirated post-

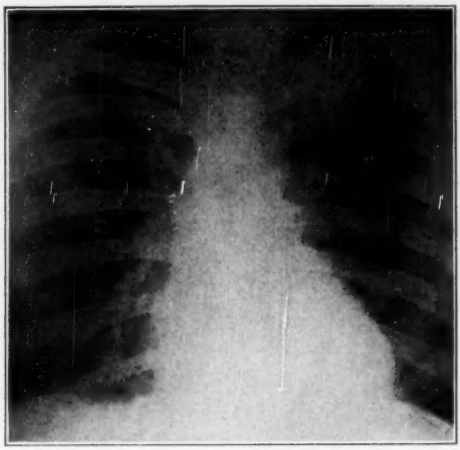

Fig. 7.—Known pulmonary tuberculosis; nonelective resection because of tuberculoma. It is often difficult to differentiate between tuberculoma and carcinoma of the lung. Compare with figure 8 *C*, which shows the roentgenogram of a proved carcinoma of the lung.

operatively. If, however, gross contamination of the pleural cavity occurs during the operation, the same mixture is placed in the pleural cavity, but the pleural cavity is aspirated and the mixture reinstilled on three successive days after operation.[8] At the completion of the operation the pressure within the pleural space is reduced to a negative one. Drainage of the pleural cavity is used only when the lower or middle lobes are removed. After operation the patient remains in an oxygen

8. Brantigan, O. C., and Rigdon, H. L.: Sodium Tetradecyl Sulfate, Azochloramide and Sulfanilamide Mixture in the Prevention of Empyema Following Pneumonectomy with Contamination, J. Thoracic Surg. **16**:416, 1947.

tent for one to five days. The patient who has undergone pneumonectomy is kept in the oxygen tent longer than the one who has been subjected to lobectomy. About eighteen days after operation a medical regimen is again started.

Previous to the use of streptomycin, the incidence of spread of tuberculosis after lobectomy was rather great and the mortality rate after pneumonectomy was exceedingly high, probably because of spread

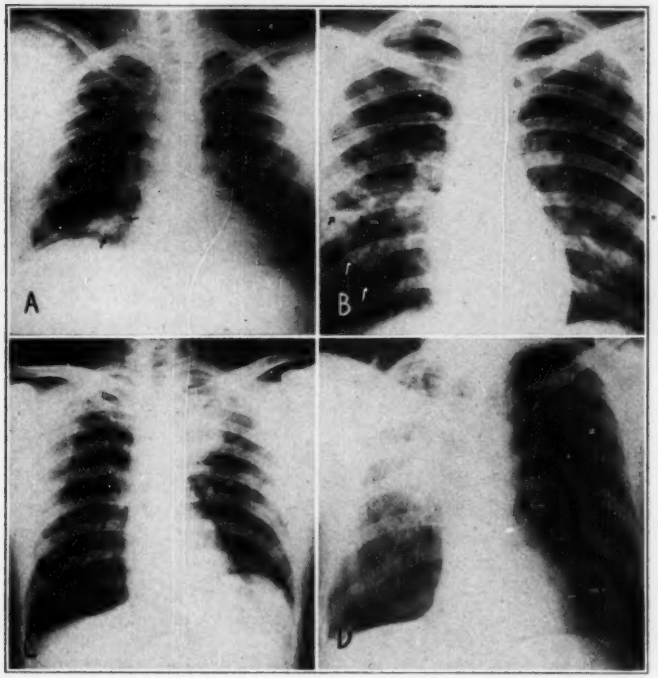

Fig. 8.—Roentgenograms of patients with questionable pulmonary disease. *A* and *B*, roentgenograms of patients who had negative reactions to bacteriologic tests for pulmonary tuberculosis. They were suspected of having the disease, but it could not be proved until pathologic studies were made of the excised tissue. *C*, roentgenogram of a patient who was treated for pulmonary tuberculosis for thirteen months, during which time two specimens of sputum and one test of fasting gastric contents revealed tubercle bacilli. These reactions finally were suspected of being false positive ones, and at operation carcinoma of the lung was found. After removal, careful examination of the lung revealed no evidence of tuberculosis. Compare with figure 7, a roentgenogram showing a proved tuberculoma. *D*, the roentgenogram of a patient with a long history of known pulmonary tuberculosis. By means of roentgenographic studies a new lesion was located. A diagnosis of tuberculosis and carcinoma of the lung was suspected before death and confirmed at autopsy.

of the disease. It was difficult to maintain enthusiasm for resection as a method of treatment of pulmonary tuberculosis because of the high morbidity and mortality rates. However, after streptomycin was available the immediate postoperative spread of disease seemed to disappear and the mortality rate was reduced tremendously. It provided a definite impetus to this method of treatment. The majority of the resections

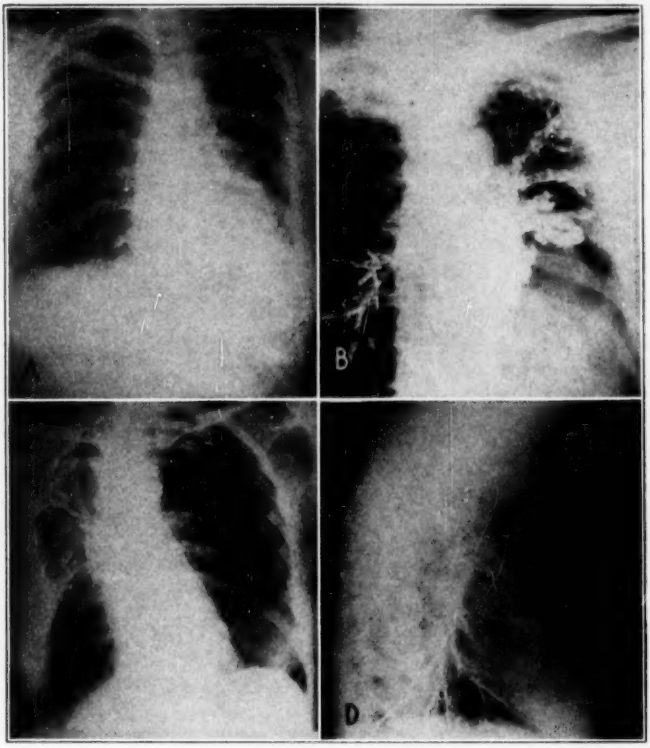

Fig. 9.—Apparently arrested pulmonary tuberculosis. The patient with definitely proved pulmonary tuberculosis may be cured, but nevertheless recurring attacks of fever, cough and expectoration may develop. It is difficult to be certain that tuberculosis does not play a part in the recurrent attacks of illness. *A* and *B*, roentgenograms of a patient who was cured by four years of sanatorium care. There were repeated attacks of illness over a nine year period, and a bronchogram revealed bronchiectasis. A pathologic examination made after resection revealed no tuberculosis of the lung. *C* and *D*, roentgenograms of a patient who was cured by a relaxing thoracoplasty. After a recurrent persistent attack of illness the bronchogram revealed bronchiectasis. A pathologic examination after resection revealed no tuberculosis.

reported here have been done since the use of streptomycin. This drug profoundly affects the tubercle bacillus and favorably influences the disease, but the treatment frequently is effective for only a short period, and more often than not the patient is not cured of his disease by its use. Therefore, the treatment with streptomycin must be considered a short term treatment. It is exceedingly effective as a protection against spread during operation. In the present series it has profoundly affected the mortality and morbidity rates immediately after operation. There is no proof that it will in any way affect the end result of resection in the treatment of pulmonary tuberculosis, since the past experience has shown that the patients who recovered from lobectomy often were free from tubercle bacilli for many months after operation, only to break down again as late as two and one-half years after the operation.

The effectiveness of collapse therapy has been based on increased rest, relaxation and collapse of the lung but not collapse by external pressure. After pulmonary resection the exact opposite factors are in force. There is really more work for the remaining pulmonary tissue, and increased tension is distributed throughout all the remaining tissue and with it, of course, overdistention. Excision should remove all known tuberculous areas of the lung; however, if one or more foci remain, more work, increased tension and overdistention of the remaining tissue will probably favor activation or flare-up of the foci.

It is also thought that after pulmonary resection overdistention of the remaining tissue and a corresponding shift of the mediastinum and the heart lead to impairment of the cardiorespiratory function. For this reason some workers have advocated routine thoracoplasty after pulmonary resection for any type of pulmonary disease.[9]

After resection for pulmonary tuberculosis there appear to be two reasons for following with thoracoplasty. It is assumed that it will prevent (*a*) the impairment of cardiorespiratory function and (*b*) activation of the remaining tuberculous pulmonary disease. There is no real proof that either assumption is entirely correct, but the latter is accepted more generally than the former. So far as cardiorespiratory function is concerned, the patient can be helped after impairment begins and therefore it has not been the practice to perform thoracoplasty after pulmonary resection for nontuberculous disease. On the other hand, if in cases of pulmonary tuberculosis thoracoplasty is withheld until activation of the disease occurs, the problem is a much graver one. Therefore, it seems reasonable to protect the patient from activation of the remaining diseased area if possible.

The risk of thoracoplasty after pulmonary resection appears rather great when it is realized that the operation is done purely as a prophylac-

9. Sweet.[3] Overholt.[4]

tic measure on a patient who is in good health. In the present series only 3 patients underwent prophylactic thoracoplasty after pulmonary resection. A search was made for an easier, safer method of preventing overdistention of the remaining lung and a shifting of the mediastinum. After experience with lucite® (a methyl methacrylate) plombage it seemed likely that lucite® ball prosthesis as described by Johnson [10] would accomplish this purpose, and it has been carried out on 15 patients. Of this group, 1 patient became infected three weeks after operation. We were not permitted to continue his treatment after infection occurred, and he died four weeks later. The use of lucite® ball prosthesis has not extended over a long enough period for evaluation. There have been no untoward effects from it except in the patient mentioned.

SUMMARY AND CONCLUSIONS

A series of 51 patients is presented on whom fifty-two pulmonary resections have been done for pulmonary tuberculosis. There were thirteen lobectomies and thirty-nine pneumonectomies performed. Streptomycin has had a profound effect on mortality and morbidity rates following resection for pulmonary tuberculosis. If proper indications are followed, pulmonary resection is a good form of treatment for this disease.

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10. Johnson, J.; Kirby, C. K.; Lazatin, C. S., and Cocke, J. A.: The Use of a Prosthesis to Prevent Overdistention of the Remaining Lung Following Pneumonectomy: A Preliminary Report, Surgery **22**:179, 1947.

SACROCOCCYGEAL TERATOMA WITH URINARY RETENTION

ROSWELL K. BROWN, M.D.
AND
ENID C. BROWN, M.D.
BUFFALO, N. Y.

TERATOMAS of the sacral region may be present at birth, lying posterior or anterior to the sacrum. They contain cysts lined by various types of epithelium, dermoids, segments of intestinal mucosa and also gland structures, fat, muscle, cartilage, bone and portions of nerve tissue.

Kiderlen [1] reported 74 true teratomas recognized in infancy and childhood gathered from the literature from 1831 to 1898. From 1900 to 1909 Parin [2] collected 21 cases, in 6 of which the tumors were malignant. Galletley [3] reported a case and reviewed 12 cases from the literature between 1909 and 1922; 3 of the tumors were malignant. Hansmann and Berne [4] tabulated 25 cases occurring from 1924 to 1930 and reported their own case; 22 of the 26 cases involved children, and 14 involved females. Since 1930 there have been more than 60 cases reported, including the 6 of Riker and Potts.[5]

In 1924 L. W. Smith [6] stated that there were 2 cases of sacral teratoma in 9,800 autopsies. Rosedale [7] found 1 case in 5,424 births at the Buffalo City Hospital from 1921 to 1933. The first case reported in this paper is apparently the only one at that institution (now the Meyer Memorial Hospital) since Rosedale's report, i. e., 1 case in 3,500

From the departments of surgery and pediatrics of the University of Buffalo Medical School.

1. Kiderlen, F.: Die teratoiden Geschwulste der Kreuzbeingegend, Deutsche Ztschr. f. Chir. **52**:87-151, 1899.

2. Parin, W.: Beitrag zur Kenntnis der angeborenen präsakralsitzenden Geschwulste, Deutsche Ztschr. f. Chir. **123**:584-600, 1913.

3. Galletley, A.: Presacral Tumors of Congenital Origin, J. Obst. & Gynaec. Brit. Emp. **31**:226-242, 1924.

4. Hansmann, G. U., and Berne, C. J.: Sacrococcygeal Teratomata, Arch. Surg. **25**:1090-1097 (Dec.) 1932.

5. Riker, W., and Potts, W. J.: Sacrococcygeal Teratoma in Infancy: A Report of Six Cases, Ann. Surg. **128**:89-100, 1948.

6. Smith, L. W.: Report of Sacrococcygeal Tumor in a Filipino Infant, Philippine J. Sc. **24**:613-619, 1924.

7. Rosedale, R. S.: Sacrococcygeal Teratoma: Report of Case, Am. J. Path. **11**:323-334, 1935.

autopsies. Pemberton [8] concluded that ventral tumors of the sacrum occurred in about 1 in 40,000 patients registered at the Mayo Clinic and that a small percentage were congenital. Chaffin [9] stated that from the calculations of Calbel and Fochier the incidence of sacrococcygeal tumors was 1 in 34,500 births. At the Buffalo Children's Hospital there was only 1 case of sacrococcygeal tumor (our case 2) during the past ten years when the total number of patients admitted to the hospital was about 75,000, the total number of individual pediatric patients in clinic and hospital about 60,000 and the total number of autopsies 1,439.

Fig. 1 (case 1).—Photograph of sagittal section.

Case 1.—S. B., a female infant, died at birth on Aug. 1, 1943, in the service of Dr. Edward G. Winkler at the Meyer Memorial Hospital. The estimated period of gestation was seven months. Pulsations of the cord were palpable, but the infant did not breathe. Administration of oxygen and artificial respiration were unsuccessful. The abdomen was grossly distended. In the sacrococcygeal region there was a tumor as large as the infant's head. The feet showed bilateral equinovarus.

8. Pemberton, cited by Love, J. G., and Moersch, F. P.: Sacrococcygeal Teratoma in Adult: Report of Case, Arch. Surg. **37**:949-955 (Dec.) 1938.

9. Chaffin, L.: Clinical Aspects of Sacrococcygeal Teratoma, Surg., Gynec. & Obst. **69**:337-341, 1939.

The postmortem examination was performed by Dr. Samuel Sanes. There was a huge tumor mass in the region of the buttocks (fig. 1). The anus was pushed anteriorly and distorted; it opened on the anterior surface of the mass. The rectum, genital organs, bladder and ureters were pushed up anteriorly by the mass, which extended from the pelvis into the abdominal cavity. The tumor measured 11 by 7 by 8 cm. It was situated anterior to the sacrum, and it contained solid and cystic areas. The final diagnosis was sacrococcygeal teratoma with extension into the retroperitoneal abdominal cavity and displacement of the organs, club deformity of the feet and fetal atelectasis.

Case 2.—F. A., a female infant born on April 25, 1945, was operated on elsewhere at 3 months of age for removal of a tumor in the right buttock. The tumor mass was said to be about 3 cm. in diameter and situated to the right of the sacrum, distending the tissues of the buttock and having no deep connections. The pathologic diagnosis at that time was hemangioma. At 4 months of age she was hospitalized for acute retention of urine with "contracture of the bladder neck

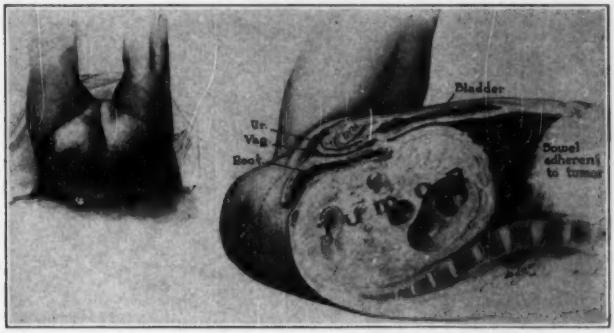

Fig. 2 (case 2).—Schematic sagittal section based on roentgenologic studies, operative findings and pathologic specimen. Note the protrusion of buttocks and scar of previous operation. The bladder is situated above the pubes. The abscess apparently involved one of the large gutlike cysts. The tumor was firmly fixed to the concavity of the sacrum.

due to unknown cause." Intravenous pyelograms showed bilateral hydroureter and hydronephrosis. A cystogram showed a smooth bladder, enlarged to the umbilicus and pushed slightly to the left. There was no backflow up either ureter. Catheterization was done daily for nineteen days, with catheters of increasing size. Sulfathiazole was given to prevent urinary infection, but on the tenth day fever developed, with pyuria. Staphylococcus aureus and Bacillus coli were cultured from her urine. On the twenty-second day in the hospital she began to refuse feedings and diarrhea developed. She became dehydrated and anemic. Parenteral administration of fluids and transfusion were followed by some improvement. On the forty-sixth day she was discharged weighing 10 pounds 6 ounces (4.6 Kg.), which was 4 pounds (1.8 Kg.) less than on her admission.

On a whole cow's milk formula, she gained 2 pounds (0.9 Kg.) in one month. The mother reported that the baby urinated frequently in small amounts. Examination of the urine showed some white cells, but there were no bouts of fever.

At 7 months of age she was hospitalized for drainage of an ischiorectal abscess which was found to extend high in the pelvis. Culture of the abscess showed Staph. aureus. The postoperative course was satisfactory. At 8 months of age a firm immovable mass was found by abdominal palpation at the brim of the pelvis. At that time there was still a small amount of drainage from the pelvis. The perineum bulged caudad and forward, there being a large protrusion between the anus and the sacrum. The thighs were held acutely flexed and abducted in a peculiar froglike posture. Rectal examination revealed atony of the anal sphincter and a large firm mass completely filling the pelvis and pressing the rectum firmly

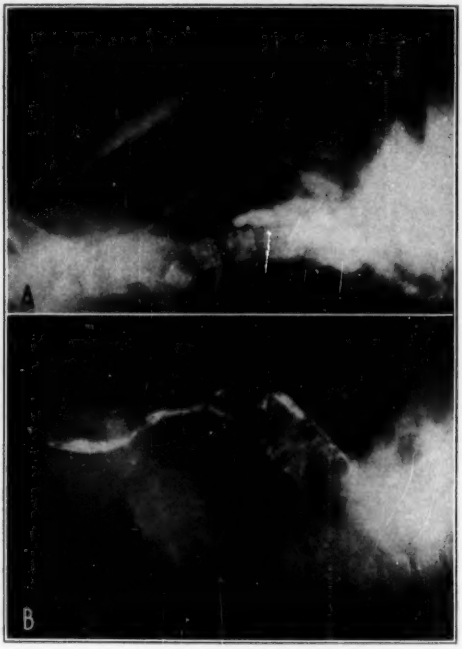

Fig. 3 (case 2).—*A*, lateral roentgenogram after intravenous injection of diodrast.® Note the bladder shadow, high in the abdomen. Both ureters were dilated. (Courtesy of Dr. G. N. Scatchard, roentgenologist at Buffalo Childrens Hospital.) *B*, lateral roentgenogram after barium enema. Note the anterior displacement of the rectum and sigmoid and the great distance between the anus and sacrum.

against the pubes (fig. 2). Roentgenograms of the abdomen showed the pelvic mass containing some areas of calcification. Intravenous pyelograms at this time showed bilateral hydroureter and hydronephrosis and the bladder distended to the umbilicus, pushed upward, forward and to the right by the mass in the pelvis (fig. 3 *A*). A barium enema showed the rectum and sigmoid pushed forward (fig. 3 *B*). The mass measured approximately 10 cm. in diameter.

Operation was performed on Jan. 8, 1946. The preoperative diagnosis was neurenteric tumor. The fistula of the right buttock was excised, and the wound was extended into the pelvis along the right border of the sacrum. The tumor mass was dissected free from the structures which surrounded its lower pole. The sacral wound was then packed with gauze, and the infant was turned over and a vertical incision made from the umbilicus to the pubis just to the right of the midline. The tumor was found extending into the peritoneal cavity, with adhesions to a loop of small bowel. It was a large, firm, thick-walled, cystic mass firmly attached in the small pelvis, displacing the bladder and rectum forward against the symphysis pubis and the anterior abdominal wall. The right ureter was seen and preserved; the left ureter and the internal genitalia were not identified. The upper pole was easily freed, and the peritoneal cavity was closed and packed

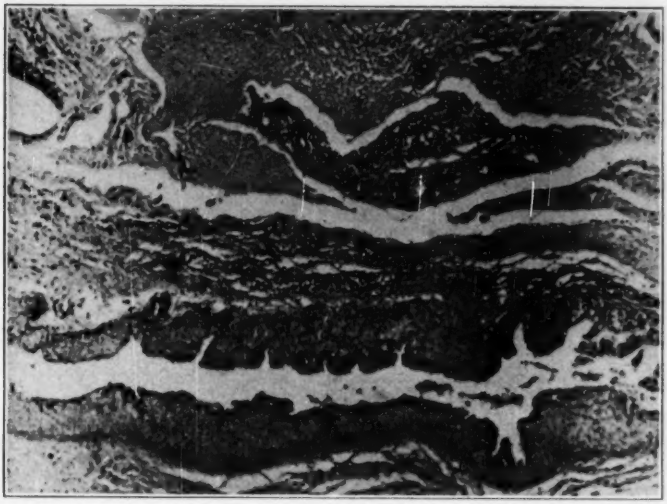

Fig. 4 (case 2).—Photomicrograph shows ductlike spaces lined by stratified squamous and columnar epithelium resting on loose connective tissue. The more compact intervening tissue is neuroglia, usually seen in the cerebrum.

cephalad. The tumor was dissected out of the pelvis by sharp and blunt dissection, considerable force being used. The anterior surface of the sacrum was stripped bare; no sacral stalk of the tumor was identified. Several cysts were broken during the operation, and the field was contaminated with pus. The tumor was apparently completely removed. The abdominal wound was closed in layers snugly, and the sacral wound was coapted loosely, a small gauze strip being left in the pelvic space.

During the operation, the patient received fluids intravenously and a transfusion. After operation there was a stormy course of fever, diarrhea and dehydration. Several transfusions, parenteral feedings, sulfonamide compounds and penicillin were administered. A catheter was kept in the bladder for the postoperative period. Culture of urine showed Bacillus aerogenes and gram-positive cocci. An abdominal

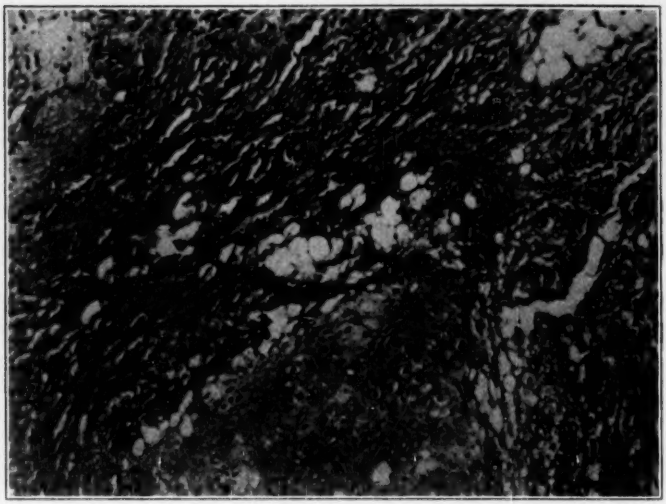

Fig. 5 (case 2).—Photomicrograph shows island of cartilage surrounded by collagenous tissue containing some fat.

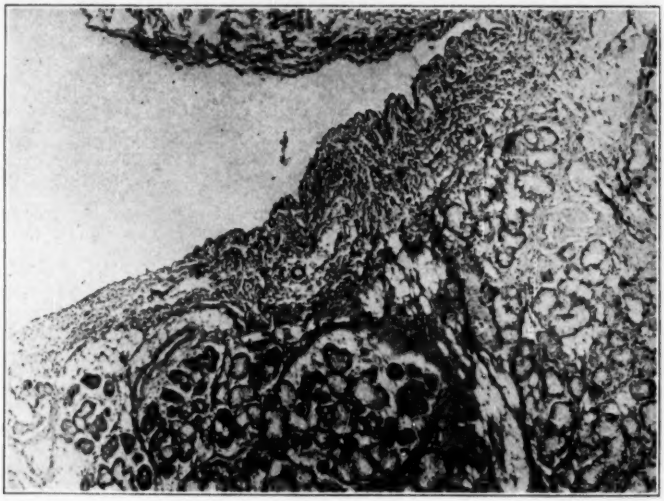

Fig. 6 (case 2).—Photomicrograph shows ductlike space lined by columnar epithelium in a single layer. In the wall there are numerous mucous glands similar to salivary glands.

fecal fistula developed and healed spontaneously. Culture of the drainage from the sacral wound showed Staph. aureus and B. coli. The infant left the hospital on the eighteenth postoperative day, still having a daily rise of temperature to about 101 F. The mother was taught to catheterize her every six hours. Gain in weight was consistent, and the wound healed satisfactorily except for a perianal fistula. There were continued atony of the anal sphincter and considerable eversion of the anal mucosa.

Two months after the radical operation, intravenous urograms with iodopyracet injection (diodrast®) showed persistent bilateral hydronephrosis and hydroureter. The infant was voiding normally at that time, but there was 60 cc. of residual urine.

On May 8, 1946, when the patient was 1 year of age, a suprapubic cystostomy was performed for chronic urinary retention. It was hoped that a period of decompression would allow the bladder and ureters to assume a more normal size and function. The bladder had a capacity of 150 cc. There was marked trabeculation of the upper part, but the trigone and the neck appeared normal except for enlargement of the ureteral orifices. Palpation with one finger in the bladder and another in the rectum revealed no evidence of remaining tumor. The cystostomy opening was well tolerated by the infant, but its management at home proved a burden and it was allowed to close three weeks later during the course of rather severe rubeola.

The child grew normally and began to walk at 15 months. Pyelograms were normal in September 1948. She micturated and defecated normally with ordinary control, but there was incontinence of feces during excitement. There were recurrent small perianal abscesses with drainage at various sites about the anus. On October 4 a dense perianal and perirectal fistulous tract was excised. There was no evidence of recurrence of tumor either grossly or microscopically.

She now has the appearance and behavior of a normal 4 year old child. There is still slight incontinence during excitement, apparently due to scar contracture deformity of the anus. Surgical correction of this defect is planned, to consist of scar excision and reconstruction of an anococcygeal raphe of normal length.

The tumor specimen was examined by Dr. Kornel Terplan. It showed the pattern of an organoid structure, an adult teratoma. It contained the three germinal layers: (1) ectoderm (fig. 4)—squamous epithelium with minimal keratinization, areas of central nervous tissue, mostly glia, and many peripheral nerves; (2) mesoderm (fig. 5)—many connective tissue fibers, adipose tissue, smooth and striated muscles, cartilage and blood vessels in fairly regular arrangement throughout the tumor; (3) endoderm (fig. 6)—channels resembling colon, bronchus-like structures and various small cysts lined by different types of epithelium.

COMMENT

The characteristics of the individual case as well as the course depend largely on the situation and size of the tumor. Ewing[10] stated that one third of the fetuses with sacrococcygeal tumors are born dead and that 90 per cent of the others die soon after birth. Externally situated teratomas are occasionally carried through adult life. Intrapelvic or intra-abdominal enlargement threatens postnatal life. The

10. Ewing, J.: Neoplastic Diseases, Philadelphia, W. B. Saunders Company, 1928.

tumors are usually firmly fixed to the sacrum. Although they displace the rectum and anus anteriorly, obstruction of the bowel is not a common feature. Urinary retention is a serious complication.

The patient in case 1 died of atelectasis, possibly partially due to the abdominal distention caused by the retroperitoneal tumor. If the infant had survived, it would have presented a clinical picture the same as that in case 2, but more obvious.

Case 2 is strikingly similar to many others.[11] Urinary retention and formation of abscess within the tumor made the prognosis seem grave. It was not until after these complications were treated that the nature of the condition was suspected. Probably this teratoma originally had the characteristic dumbbell or hourglass shape. The outer portion was removed at the age of 3 months and the inner portion at the age of 8½ months. The tumor apparently involved much of the nerve supply of the bladder and anus. It seems obvious that the infant with a large or growing presacral tumor should have the benefit of wide surgical excision as soon as the diagnosis is made.

SUMMARY

Two cases of sacrococcygeal teratoma are reported. One patient died at birth with fetal atelectasis. The other underwent excision of a gluteal tumor at the age of 3 months, had acute retention of urine at 5 months and drainage of ischiorectal abscess at 7½ months, presented a presacral tumor which was removed through parasacral and abdominal incisions at 8½ months, was subjected to suprapubic cystostomy at 12½ months and showed normal development at the age of 3½ years with relative atony of the anal sphincter.

11. Arnheim, E.: Personal communication to the authors. Riker and Potts.[8] Chaffin.[9]

GENERALIZED GIANT HYPERTROPHIC GASTRITIS SIMULATING NEOPLASM

Differential Diagnosis and Report of a Case

JAY P. BARTLETT, M.D.
AND
WILLIAM E. ADAMS, M.D.
CHICAGO

IN A COLLECTIVE review of medical publications up to July 1942, Pack and McNeer reported only 2 total gastrectomies for benign lesions among 303 authenticated total gastrectomies. Wier stated that 9 total gastric resections have been performed for benign gastric lesions at the Mayo Clinic between 1935 and 1944. Jones (1945) reported 2 resections for benign ulcers close to the cardia among 8 total gastrectomies in which no postoperative deaths occurred. The case being reported and 1 subsequent case observed in Billings Hospital are the only 2 of generalized hypertrophic gastritis in which total gastrectomies are known to have been performed.

Hypertrophic gastritis is characterized by hypertrophy and hyperplasia of the gastric mucosa. Focal areas of mucosa or, as in the case reported, nearly the entire mucosa may be involved. Only 45 cases of hypertrophic gastritis have been found in which the diagnosis has been supported by pathologic studies (see table). In 7 of these cases the diagnosis was based on biopsy, in 9 on autopsy and in 29 on the surgical specimen. In several verified cases the pathologic descriptions are insufficient to afford a detailed comparison.

In addition to these 45 cases, Schindler reported 23, Sprigg 16 and Benedict 117 cases of hypertrophic gastritis in whch the diagnosis was based on roentgenologic and gastroscopic examinations; Pollard and Cooper 1 case based on roentgenologic examination alone and another on roentgen examination and exploratory laparotomy; Kirklin and Broders 1 case based on roentgen examination and exploratory laparotomy, and Cole 4 cases based on roentgen examination alone. These total 163 cases in which there was no pathologic study, reported in conjunction with cases in which pathologic studies were included.

Reports of other cases in which pathologic studies were not carried out have not been noted in the table, but they may give more complete information regarding the reported incidence of hypertrophic gastritis.

From the Department of Surgery of the University of Chicago.

Cases Reported to 1946

Date	Author	No. of Cases	Diagnosis Based on	Comment
1880	Andral	1	Autopsy	Cited by Brunn and Pearl and Myer
1888	Menentrier	2	Autopsy	Cited by Brunn and Pearl and Myer; total involvement absent
1913	Myer *	1	Autopsy	Before Wassermann test was in use
1919	Balfour *	1	Surgical specimens	From 8,000 gastric operations
1920	Ruggle	1	Surgical specimen	Middle one third involved; resembled brain cortex; micropathologic study included
1924	Brams	1	Surgical specimen	Pyloric hypertrophic gastritis
1925	Eliason and Wright	1	Autopsy	From 8,000 autopsies
1926	Pearl and Brunn	1	Biopsy	Verified pathologic changes
1928	Strauss, Meyer and Bloom	2	Surgical specimen	Pathologic process described
1932	Becchini	1	Biopsy	Cited by Pearl and Brunn
1933	Cole	1 4	Pylorectomy Roentgenograms alone	Good pathologic description
1937	Schindler	23	Roentgenologic and gastroscopic examinations	From gastroscopies on 249 patients
1937	Christopher	1	Surgical specimen	"Polyadenoma en nappe"
1937	Holman	1	Partial resection	Cited by Pearl and Brunn
1938	Brunn and Pearl	1	Surgical specimen	Pathologic studies
1939	Schindler	2	Biopsy, surgical specimen	A third case reported, from Brunn
1939	Kirklin and Broders	1 1	Surgical specimen Exploratory laparotomy	A third case reported, previously by Balfour
1942	Heeks and Gibb	1	Surgical specimen	Gross and microscopic studies
1943	Sprigg	3	Autopsy, roentgenograms and gastroscopy	Seen in 4,424 cases over a period of 18½ years
1943	Benedict	1 117	Surgical specimen Roentgenograms and gastroscopy	Pathologic description; from 1,300 gastroscopic examinations
1943	Stout	1	Surgical specimen	From 225 surgical specimens and 185 autopsies; pathologist's report
1943	Feldman	1	Biopsy	Lesser curvature—seen in 25,000 roentgen examinations
1943	Freedman, Glenn and Laipply	3 2	Surgical specimen Biopsy	"Localized chronic hypertrophic gastritis"
1945	Hinkel	1	Surgical specimen	Localized proximal two thirds
1945	Pollard and Cooper	1 5 1 1	Biopsy Subtotal gastrectomies Roentgenograms alone Roentgenograms and laparotomy	Pathologists' reports
1945	Harris	1	Surgical specimen	"Hypertrophic sclerotic gastritis" in Negro with a positive reaction to the Kahn test
1946	Maimon and others	4 1	Surgical specimen Autopsy	One additional case previously reported by Schindler
1946	Banks and others	1	Surgical specimen	Good pathologic description

7 biopsies	156	roentgen and gastroscopic examination	
9 autopsies	5	roentgenologic study alone	
29 surgical specimens	2	roentgen examination and laparotomy	
45 with pathologic studies	163	without pathologic studies	

* These 2 cases are reported by Cramer as observed in 50,000 gastrointestinal examinations (Eusterman and Sentry).

In 1922 Eusterman and Sentry reported a case of hypertrophic gastritis on the basis of roentgen examination alone, and Habbe reported another in 1932. Feldman cited 2 cases observed by Kantor in 2,500 roentgenologic examinations of the stomach and 4 cases reported by Scherer. Rigler and Ericksen in 1936 reported finding 61 cases of chronic hypertrophic gastritis or hypertrophied rugae in roentgen examinations of the gastrointestinal tract of 4,236 patients, of whom 1,547 had gastroduodenal lesions.

Experimentally, the etiologic factors for hypertrophic gastritis have not been proved. Chemical, mechanical and thermal irritants may well play a role. Sprigg found the stomach of an insane patient who ate rubbish to be severely involved by hypertrophic changes. Hyperplastic reaction of the gastric mucosa in monkeys after prolonged exposure to an oil fog has been reported by Lushbaugh. Cramer has shown, on the other hand, that hypertrophic changes in the rat's stomach may be due to a vitamin-deficient diet rather than to chronic exposure to nematodes as reported by Fibiger. Choline may also be necessary to the diet of rats (Sharpless). Physiologic stimulation by protracted use of histamine has been suggested as a factor for hyperplasia (Cox and Barnes). Brunn and Pearl implied that the hypertrophic plaques en nappe variety may be telangiectatic in origin.

REPORT OF A CASE

A 42 year old white man, a United States mail carrier, was first seen on April 11, 1945, complaining of (1) a loss of 12 pounds (5.4 Kg.) of weight gradually over the past year; (2) a bloated sensation and abdominal discomfort in the epigastrium which had become gradually worse during the previous six months and was relieved by belching; (3) a dull ache in the midepigastrium, occasionally generalized in the abdomen, and occurring about two hours after meals; this ache, which had been of three to four months' duration, was relieved by mild alkalis or food or by belching and passing of flatus; (4) a loss of appetite and of general strength and stamina during the past four months; (5) emesis of an undigested meal and gastric juice once ten days before this clinic visit. The emesis contained no blood or coffee-ground discolorations. The bowel movements had been of normal character and frequency. Inquiry revealed that he drank about one-half pint (250 cc.) of whisky a week and one or two glasses of beer a day and that he was, prior to his present illness, active in physical activities outside of his work.

Physical examination revealed the following positive findings: The patient was a well developed, rather thin man appearing his stated age. His blood pressure was 110 systolic and 70 diastolic, his pulse rate 72 and his temperature and respirations normal. His remaining six teeth showed poor care. The chest and heart were normal, and the liver, spleen and kidneys were not palpable. A questionable mass had been felt on one occasion in the midepigastrium. The preoperative blood studies are of interest, for on April 30 the plasma protein content was 4.95 Gm. and the nonprotein nitrogen 30.7 Gm. per hundred cubic centimeters, the red blood cell count 4,750,000 per cubic millimeter, the hemoglobin content 14.0 Gm. and the white blood cell count 11,650, with a differential count of 75

per cent polymorphonuclear cells, 23 per cent lymphocytes, 1 per cent monocytes and 1 per cent eosinophils.

The clinical diagnosis was peptic ulcer. Fluoroscopy showed the esophagus, duodenum, colon and terminal portion of the ileum to be normal. The body of the stomach, however, showed extensive irregular polypoid protrusions and stiffening of the wall of the greater curvature. No definite ulcer crater was seen, but there were many more or less constant collections of barium between the elevations of the mucosa. The roentgen picture was one of multiple polyps in the stomach, almost certainly polypoid carcinoma (figs. 1 *A*, *B*). A gastroscope was passed easily by Dr. S. N. Maimon. He reported that no obstruction was encountered at the cardia and the pyloric canal was visualized. Enlargement of all gastric folds was striking; the folds appeared to be infiltrated as if by some neoplastic process. There were no surface ulcerations of the gastric mucosa, but the entire mucosa was hyperemic, dull red and slightly granular. The impression was one of a diffuse process involving the stomach strongly suggestive of neoplasm (Borrmann, type

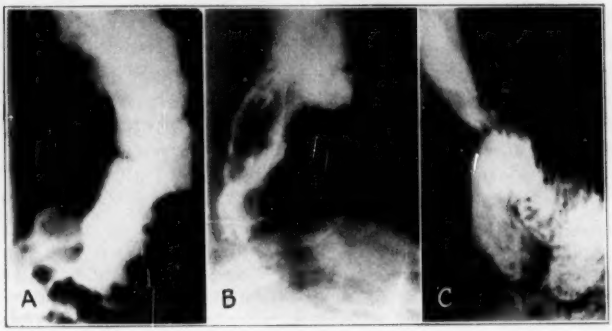

Fig. 1.—*A*, preoperative roentgenograms of the stomach, showing the marked rugal folds deforming the gastric pattern. *B*, similar view of the stomach. The rugal folds make a more pronounced filling defect when a pressure cone is used. *C*, postoperative roentgenogram demonstrating a well functioning esophagojejunostomy opening.

IV). The diagnoses of hypertrophic gastritis and lymphoma were mentioned as remotely possible.

The operative procedure was performed on April 30, 1945. Under continuous spinal and nitrous oxide anesthesia, the abdomen was explored by William E. Adams through an upper midline incision. The lower angle was extended toward the left for greater exposure. The stomach appeared large and the serosal vessels prominent. On palpation the walls seemed thickened practically throughout, the thickening being along the lesser curvature, where it was firm. Enlarged lymph nodes were present both in the gastrohepatic omentum and along the greater curvature. Frozen sections of these nodes showed only lymphoid hyperplasia. There was no evidence of metastasis, and the liver was normal to palpation. The impression was lymphosarcoma of the stomach. A total gastrectomy was performed, the lymph nodes along both the curvatures being removed. A Roscoe Graham type of anastomosis of the esophagus to the first loop of the jejunum was

done. During the operation 1,250 cc. of whole citrated blood and 1,600 cc. of isotonic sodium chloride solution were given.

The postoperative course was uneventful except for urinary retention in the first eight hours, relieved by catheterization. The highest postoperative temperature was 102 F. (38.8 C.) rectally, which occurred on one occasion on the fifth postoperative day. Twenty thousand units of penicillin every three hours intramuscularly was given for ten days postoperatively. Sulfadiazine, 0.5 Gm., was given once on the second postoperative day. The plasma protein content was 5.34 Gm. on May 5, but it had risen to 6.80 Gm. by May 14. The red blood cell count was 3,890,000 on May 8 and 3,600,000 on May 16; the hemoglobin content was 12.5 Gm. Later, on June 6, the red blood cell count was 4,200,000 and the hemoglobin 14.1 Gm. On the fifteenth postoperative day the patient was discharged home on a six meal soft diet, which he had tolerated well for four days.

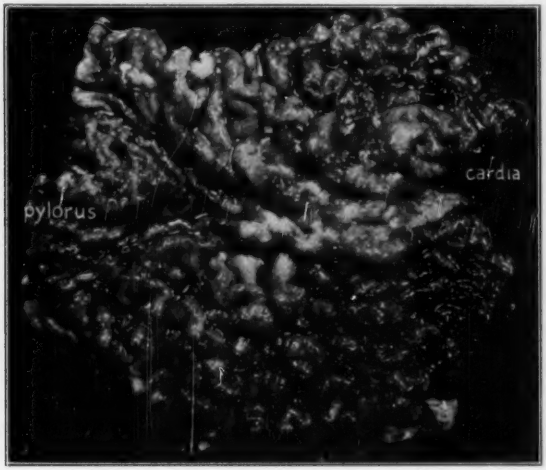

Fig. 2.—Reproduction of a colored transparency of the opened stomach, which illustrates the marked epithelial hypertrophy. Note the remarkable similarity of the rugal fold pattern to cerebral convolutions. The cardia and the pyloric valve are included in the specimen.

The patient was followed in the clinic periodically. He was doing well and had returned to his former employment by July 25, at which time flouroscopic examination with the use of barium showed a satisfactory appearance of the esophagoenterostomy opening (fig. 1*C*).

He remained well and active until six months prior to his visit on March 17, 1948, after which he was hospitalized for five days' investigation because of complaints of (1) postprandial epigastric distress for six months, (2) occasional vomiting after meals for two months and (3) inability to eat anything except soft foods and fluids for three weeks. He had recently had diarrhea after the intake of milk, cake and sweets. Examination of the systems revealed no abnormalities except a long-standing chronic cough mildly productive of gray sputum. The

physical and neurologic examination revealed no significant abnormal findings. A report of an esophagoscopic examination stated: ". . . the entire esophagus appeared normal, as did the anastomosis. The jejeunal folds appeared normal and are interesting to watch as the peristaltic waves move across the field." A report of a fluoroscopic barium examination stated: "There is a well-functioning esophagoenterostomy opening and slight dilatation of the small bowel at the region of the anastomosis with the esophagus; but this empties rapidly." The laboratory studies showed normal urine, but the red blood cell count was 3,500,000, the

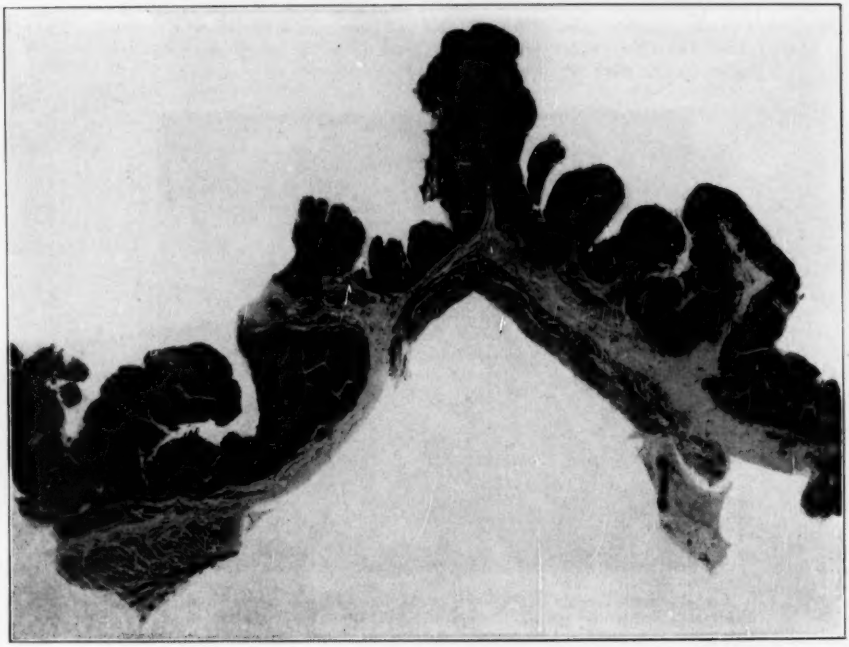

Fig. 3.—Photograph of a large histologic section through a representative part of the gastric wall, showing enlarged polyp-like rugae; × 3. [The special large microscopic sections were prepared by Henry Sollman.]

hemoglobin content 13.0 Gm., the white blood cell count 10,325, with 90 per cent neutrophils, 1 per cent eosinophils, 1 per cent basophils, 7 per cent lymphocytes and 1 per cent monocytes, and the red blood cell volume 41 per cent, with slight poikilocytosis and macrocytosis. A sternal marrow biopsy revealed erythroblastic cells diminished in numbers but normal in distribution. The blood nonprotein nitrogen was 35 mg. per hundred cubic centimeters and the plasma protein content 5.0 Gm., with an albumin-globulin ratio of 2:3. The blood carbon dioxide and chloride contents were in the normal range.

At a medical consultation it was suggested that "the diarrhea and abdominal distress is probably dietetic in origin and controllable by diet." The hematology consultant agreed that a supervised dietary regimen would clear up the symptoms and the anemia as well. Fifteen units of liver extract weekly for a few months was recommended. The patient was discharged home to receive the recommended therapy from his family physician.

When heard from on Sept. 18, 1948, he was working full time, free from gastrointestinal complaints. Recently he had had a complete civil service examination

Fig. 4.—Large microscopic section (× 15) to illustrate mucosal hypertrophy, enlarged tortuous gastric glands, cystic spaces, inflammatory infiltrations and numerous lymphocytic follicles.

in the marine hospital and was released as perfectly fit. A borderline anemia was noted, however. On November 12 he was seen complaining of dumping syndrome symptoms. He had lost no weight, and he was not working full time. The white blood cell count was 7,600 per cubic milimeter, the red blood cell count 3,700,000, the hemoglobin content 12.0 Gm. and the plasma protein content 4.7 Gm. The albumin was 3.3 Gm. and globulin 1.4 Gm., a 2: 4 ratio. Further therapy and dietary management for secondary anemia was recommended, to be carried out by his family physician.

Pathologic Findings.[1]—The stomach, the distal end of the esophagus and the proximal portion of the duodenum weighed 869 Gm., and measured some 20 by 30 cm. Before the stomach was opened thick soft poly-like masses were felt; the stomach felt as if it contained a mass of "large fishing worms." The entire mucosa was mottled reddish purple, looked edematous and had a cobblestone appearance. The rugae were more numerous than in any resected stomach observed previously.

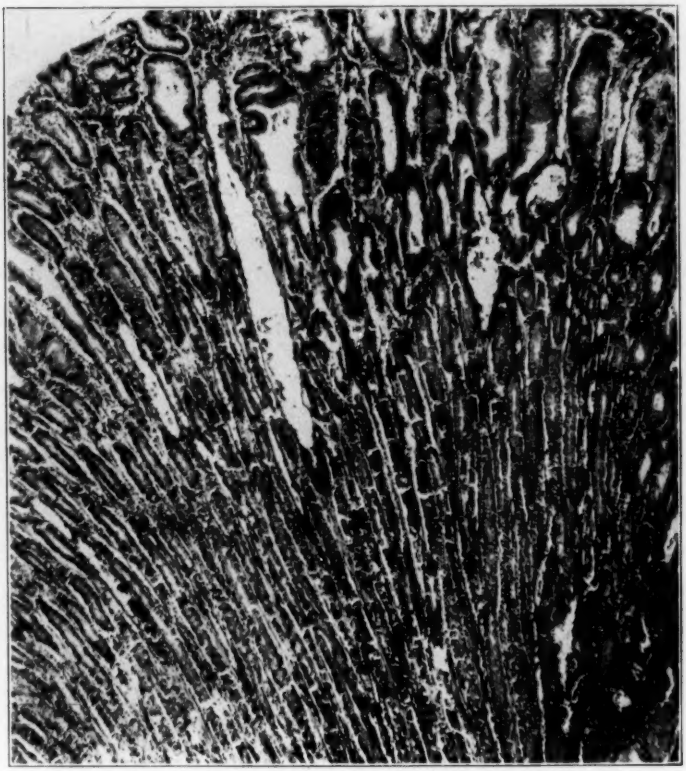

Fig. 5.—Photomicrograph (× 70) of a portion of the hypertrophic mucosa. This area illustrates crowded and lengthened gastric glands, tortuosity and dilatation of the fovea and diffuse inflammatory cell infiltrations.

They gave the appearance of convolutions of the brain; some in the lesser curvature were particularly large and packed together. The larger rugae measured 2.5 cm. in width. In this area the muscularis was especially thickened, giving an

1. Dr. E. M. Humphreys assisted with the interpretation of the pathologic changes.

over-all thickness of 5 cm. In the pyloric region the rugae were smaller and had many small areas of erosion. In the five areas from which ample-sized sections were taken the mucosa was not only freely movable but elevated by an edematous submucosal tissue (fig. 2).

As is illustrated in the large microscopic section (fig. 3), the mucosa was markedly thickened and the rugae much larger and packed more closely together than normal. The submucosa was edematous and the muscularis greatly thickened. Histologic study of the muscularis revealed only hyperplastic musculature; the mucosa, however, presented a mixed picture of inflammatory infiltrations, hypertrophy, hyperplasia and metaplasia (fig. 4).

Several of the polypoid rugae were composed of elongated gastric glands lined on the luminal surface by mucous cells and, in the deeper third to three fourths, by chief and parietal cells. The interstitial mucosal stroma was infiltrated by many inflammatory cells, some lymphocytes and polymorphonuclear cells but mainly plasma cells (fig. 5). Only rarely were there large Russell body cells, characterized by metachromatic eosinophilic cystoplasm and hyperchromatic nuclei. Other giant rugae were formed mainly by mucosa cells of columnar mucous type. The cells formed elongated serpentine fovea; numerous cystic spaces were seen along the base of the mucosa, at times extending into the lamina propia (fig. 4).

Along the lesser curvature of the gastric wall, where the mucosa was fixed, two ulcers were detected. One was a comparatively small, healing erosion which had become covered by simple columnar epithelium (Palmer and Humphreys). There was considerable inflammatory reaction in the floor of this ulcer, which lay superficial to the muscularis mucosae. The ulcer seemed to represent a healing erosion (Caylor). The larger ulcer occupied the valley between two tall rugae and was almost concealed by overhanging hypertrophied mucosal folds. The floor lay well below the muscularis mucosae and was composed of granulation tissue bathed with pus. Lying in the floor was the remnant of a large thrombosed artery, which had lost by erosion the superficial portion of its wall. In the vicinity of the lesion the submucosa was scarred and the wall was heavily invaded by inflammatory cells. Plasma cells and eosinophils were abundant. Lymphocytic follicles were especially prominent. Other arteries, possibly branches of the eroded artery, showed proliferative intimal thickening.

In a few areas, mainly superficially, mucous cells were stained deeply with basic hematoxylin and exhibited pleomorphic character. The nuclei were often without polarity to the basement membrane. No actual invasion of the mucosal cells into the lamina propia or submucosa was seen, however.

COMMENT

This case serves to illustrate many of the features frequently associated with hypertrophic gastritis, although no typical clinical syndrome is apparent. Horner, in his discussion of the symptomatology in 50 cases of hypertrophic gastritis, enumerated the complaints in their order of frequency. Distress or pain in the upper abdominal area, somewhat ulcer-like in character but inconstantly relieved by the intake of foods or alkalis and of a variable duration, is frequently the presenting complaint, as it was in this case. Vague abdominal distress, nausea and emesis, anorexia, weakness and weight loss, diarrhea and headache have been noted less frequently. Anemia is sometimes present. This

may, in part, result from an inadequate dietary intake, associated with the gastrointestinal symptoms. Hemorrhage from the gastrointestinal tract does occasionally occur (Maimon and others; Pearl and Brunn; Schindler; Strauss and others). Obstructive symptoms may be present with antral involvement, especially if polyps or redundant mucosal folds are present Bralow; Cole; Pearl and Brunn; Scott).

Hypoproteinemia was observed preoperatively in 2 of the 6 cases discussed by Maimon. As a rule, free gastric acidity has been found (Schindler; Maimon and others). In the case of Strauss and others and that of Christopher, however, there was no free acid on stimulation with histamine. In the latter case a pathologic picture suggestive of carcinoma in situ was present. In a case described by Maimon and others, in which numerous polyps exhibiting metaplasia of the mucosa without invasion of the base and loss of acid-secreting cells were superimposed on hypertrophic gastritis, no free acid was present.

This case report illustrates that to differentiate hypertrophic gastritis from polypoid carcinoma, lymphosarcoma, multiple adenomatous polyps and, less commonly, leiomyosarcoma, Hodgkin's disease, uncommon benign lesions and, rarely, syphilis of the stomach by roentgenologic and gastroscopic examination is extremely difficult and at times impossible.

Berridge remarked that roentgenologically it is impossible to be certain of the diagnosis of the chronic verrucous form of gastritis. He mentioned that variations in the tonus of the gastric musculature and an inconstant degree of distention with air give frequent errors in gastroscopic diagnosis in cases of hypertrophic gastritis. Ricketts recently reported 3 cases which illustrate this gastroscopic difficulty.

Templeton stated that the roentgenologic characteristics of hypertrophic gastritis are such that, as a rule, a definite differentiation from malignant lesions cannot be made in the absence of serial microscopic sections. Illustrating the problem of making a consistently accurate diagnosis, Schindler discussed 3 cases of hypertrophic gastritis, Freedman 3 cases, Hinkel 1 case and Pearl and Brunn 2 cases in which the true nature of the disease could not be diagnosed with certainty until histologic studies were made. This problem was similarly present in the majority of the cases discussed by Maimon. Benedict discussed 5 cases in which the differential diagnosis was unsettled until pathologic examination was made. In another report he discussed the correlations of gastroscopic, roentgenologic and pathologic findings in 245 cases studied by these means. He concluded that the differentiation of hypertrophic gastritis from carcinoma may be impossible.

Judging from cases in which detailed pathologic studies are available, the case here reported probably lies between the extremes of variation of the over-all pathologic picture. In general, the gastric rugae involved

by the disease are grossly larger, their sulci are deeper and their contour more serpiginous than those normally seen. Local areas or nearly the entire mucosa may be involved, resembling cerebral convultions as first described by Menentrier.

Microscopically, the mucosa may show hyperplasia of its cellular elements in normal proportions; or it may show varying degrees of replacement of the acid-secreting (oxyntic) cells, the zymogenic cells and the argentophilic (Paneth) cells by the more superficial mucous type cells. These last cells may exhibit metaplastic changes resembling lower intestinal mucosa. Often there are seen mucous cell–lined cystic spaces and at times marked hyperchromic bizzare nuclei, the cells of which have lost orientation to basement membranes. This degree of metaplasia is at times indistinguishable from true neoplasia.

Invasion beyond the mucosa has not been reported except for the case recorded by Christopher. In that case there was shallow invasion of the submucosa by "diffuse adenocarcinomatous metaplasia of the gastric mucosa." Polypoid extensions from the hypertrophied mucosa may also occur. Infiltration of inflammatory cells may be seen throughout the mucosa, more rarely extending into the submucosal layer. Whether this inflammatory infiltration is part of the primary process or secondary to the hypertrophy, hyperplasia and metaplasia is open to question.

It is because of the unknown nature of the pathologic process and the at times suspicious resemblance to early carcinomatous changes that hypertrophic gastritis demands serious consideration with regard to its proper treatment. It is the type of gastritis with which Ewing admitted the most difficulty in the determination of the malignancy of the lesion. He remarked that "it was in this particular group that the twenty famous pathologists whom Cole put on the gridiron failed to reach a conclusion." Warren and Meissner liken epithelial metaplastic changes of the mucosa in chronic gastritis to premalignant changes of other organs such as the cervix, breast and skin. They stated that "it may be assumed that some gastric cancers arise from this lesion." But they also wrote: ". . . it does not follow that all severe gastritis will become carcinoma, or that all cancers arise on the basis of chronic gastritis." Guiss and Stewart's studies agree with these conclusions in that they found no evidence for the Virchow-Knojetzny theory that carcinoma of the stomach is the result of chronic inflammation.

That adenomatous polyps not uncommonly undergo malignant degeneration is fairly well accepted (Barrett; Eliason and Wright; Heeks and Gibb; Nettleship; Pack and McNeer; Pearl and Brunn; Rigler and Ericksen; Wright and Eliason). The large hyperplastic polyps which are associated with chronic hypertrophic gastritis should be regarded as potentially precancerous on the basis of observed meta-

plastic changes. The use of biopsy of frozen sections during operation in an attempt to differentiate carcinoma and especially lymphosarcoma from giant hypertrophic gastritis may meet with considerable difficulties. The incidence of lymphosarcoma is greater than many suspect, for over 500 cases have been reported in medical periodicals (Rafsky and others).

The possibility of gastric hemorrhage from peptic ulceration is well illustrated in this case report by one of the microscopic sections which demonstrates gastric ulceration onto a large artery. Gastric polyps have been mentioned before as a not infrequent source of gastric hemorrhage (Maimon and others; Pearl and Brunn; Schindler; Strauss and others).

The postoperative mortality rate for total gastrectomies has decreased appreciably according to recent reports. An insufficient number of total gastrectomies have been performed for benign gastric lesions to give separate mortality figures. Pack and McNeer gave the combined postoperative mortality as 37.6 per cent for the 298 cases of total gastrectomy collected by them. There were 6 postoperative deaths in their 20 cases. A lower perecntage of 34.3 is reported for the latest 166 cases reported by them between 1931 and July 1942. Marshall and Brown reported the mortality as 16.3 per cent for 49 total gastrectomies performed at the Lahey Clinic between 1942 and 1947. Previously, Lahey and Marshall reported the operative mortality for 73 cases collected from 1927 to 1944 as 33 per cent. Neibling and Walters stated that the immediate over-all hospital fatality rate was 39.6 per cent for 124 total gastrectomies performed from 1917 to 1945 at the Mayo Clinic, but from 1917 to 1939 this figure was 60.6 per cent and for 20 cases in 1943 only 25 per cent (Waugh and Faklund). Milanes and others reported an immediate postoperative mortality of 27 per cent for 13 cases from the Habana Medical School. Jones reported 8 and Moreland reported 6 total gastrectomies without any postoperative deaths. The longest survival period recorded after total gastrectomy is eight years; Pack and McNeer reported a survival of this length in their review, and Wier reported another after gastrectomy for a benign ulcer.

The immediate postoperative complications of total gastrectomy for benign lesions are essentially similar to those following such a procedure for malignant lesions. The problem of metastasis or recurrence, of course, need not be considered. It is of interest that death in 2 cases of hypertrophic gastritis followed leakage of the anastomosis due to incomplete removal of the diseased tissue (Schindler; Hinkel; Benedict).

Symptoms following total gastrectomy are essentially similar to those following subtotal gastrectomy for benign lesions. The most troublesome symptoms result from malnutrition and associated hypochromic anemia. This difficulty responds well to instruction for high

protein and carbohydrate dietary management plus additional iron therapy (Berkman and Heck; Pack and McNeer). No true pernicious anemia from total gastrectomy has been reported, either clinically or experimentally (Bursabarger and others; Graham and Mann; Ivy and others; Mann and Graham; Mullenix and others). The second most troublesome symptom is the "dumping syndrome." Berkman found that dietary instruction for frequent, small meals and a gradual change toward the normal habits is sufficient to correct this symptom. The authors have had similar experience with the case herein reported.

CONCLUSIONS

In consideration of the case reported and other similar cases in this clinic, as well as information obtainable from current medical literature, it would seem that surgical treatment of generalized hypertrophic gastritis by total gastrectomy may be recommended on the following basis:

1. The extreme difficulty of correctly diagnosing this lesion on the basis of clincal history, physical examination, roentgen examination and gastroscopic examination.

2. The similar difficulty of correctly diagnosing the lesion grossly, or even with the aid of biopsy of a frozen section during operation.

3. The probable premalignant status of stomachs severely involved by this disease.

4. The danger of fatal peritonitis following a break of the suture line when resection is not beyond the diseased tissue.

5. The definite possibility of dangerous hemorrhage, obstruction or malnutrition, which may be the natural course of the disease when treated by conservative medical management.

6. The generally lowered mortality rate of total gastrectomy and the minimal long term postoperative complications, which today offer chances of long survival in comparative comfort.

SUMMARY

A case of generalized hypertrophic gastritis treated by total gastrectomy is reported. One subsequent similar case is cited. The pathologic features as well as the difficulties of clinical diagnosis and treatment are discussed. The basis for recommended surgical treatment is given. The readily available medical periodicals (in English) have been reviewed through January 1948.

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LEIOMYOMA OF THE ESOPHAGUS

ALFRED GOLDMAN, M.D.
AND
HAROLD MASTERS, M.D.
BEVERLY HILLS, CALIF.

THE REMOVAL of benign tumors of the esophagus has now become a practical procedure because the accompanying surgical mortality and morbidity are minimal. Leiomyomas occur chiefly in the distal third of the esophagus. Because of their rarity, the difficulty in visualizing this esophageal area in roentgenograms, the presence of concomitant overshadowing lesions and the failure to perform esophagoscopic examination or interpret the findings properly, the correct diagnosis has been frequently missed.

It is the purpose of this paper to summarize the pertinent literature and to report successful removal of leiomyomas of the esophagus in 2 cases.

INCIDENCE

About 200 case reports of esophageal benign tumors are on record.[1] A wide variety of benign esophageal growths have been reported. Besides leiomyomas, authors have described adenoma,[2] fibroma,[3] hemangioma,[4] lipomyoma,[5] myoma,[6] myxofibroma,[7] neurofibroma,[8]

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From the Thoracic Surgical Service, Cedars of Lebanon Hospital.

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8. Neurofibroma of the Esophagus, Cabot Case, no. 23491, New England J. Med. **217**:955-958, 1937.

fibromyoma,[1] papilloma,[9] polyp [10] and osteochondroma.[11] These tumors occur at any age and have no predilection for sex. Most of them are symptomless during life and are not diagnosed before death. Consequently the great majority are found incidentally during routine roentgenographic examination or autopsy. Moersch and Harrington [12] reviewed a series of 7,459 autopsies and found 44 benign esophageal tumors not diagnosed during life. Thirty-two of these were leiomyomas. Schafer and Kittle [13] investigated a group of 6,001 autopsies and noted 11 benign tumors. Patterson,[1] in a review of the literature from 1717 to 1932, found 62 reported cases of benign tumors. Adams and Hoover,[14] reviewing the literature for the following eleven years, found 29 additional cases. Aside from the incidence of apparently symptomless tumors discovered at autopsy, it has been found that only 15 benign tumors were present in 11,000 patients complaining of dysphagia.[12] The rarity of leiomyoma of the esophagus is emphasized by these statistics. On the other hand, malignant tumors are approximately ten times more frequent. Thus, in a study of 17,947 autopsies, 204 carcinomas of the esophagus were found.[15]

SURGICALLY RESECTED LEIOMYOMAS

In spite of the relatively large number of leiomyomas discovered incidentally at autopsy and at clinical examinations, we could find only 7 cases reported in which surgical resections were performed (table 1). Ohsawa [16] in 1933 apparently did the first successful removal of leiomyoma of the esophagus. He reported the case of a 43 year old woman who had a twenty-four year history of dysphagia. A diagnosis of "idiopathic esophageal dilatation" was made, and an exploratory thoracotomy was performed. A submucosal leiomyoma, 1 cm. in diameter, was found and removed. The patient had an uneventful convalescence.

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13. Schafer, P. W., and Kittle, C. F.: Esophageal Leiomyoma: Report of Successful Resection, J. A. M. A. **133**:1202-1205 (April 19) 1947.

14. Adams, R., and Hoover, W. B.: Benign Tumors of Esophagus, J. Thoracic Surg. **14**:279-286, 1945.

15. Sauerbruch, F., and O'Shaughnessy, L.: Thoracic Surgery, William Wood & Company, 1937, pp. 332-333.

16. Ohsawa, T.: Surgery of the Esophagus, Arch. f. jap. Chir. **10**:605-700, 1933.

TABLE 1.—*Data on Surgically Resected Leiomyomas Reported in the Literature*

Author	Age	Sex	Symptoms	Roentgenologic Picture	Esophagoscopic Diagnosis	Preoperative Diagnosis	Size	Location	Result
Ohsawa, 1933...	43	F	Dysphagia 24 yr.	.....	.....	Cardiospasm	1 cm.	.....	Satisfactory
Harrington and Moersch, 1944	39	M	None	Deformity of lower end of esophagus; increased density on left side of heart	Deformity, with angulation of lower end of esophagus	Esophageal tumor	.....	Lower 5 inches involved—entire wall and circumference	Died
Harrington and Moersch, 1944	56	F	Pain beneath xiphoid process; gagging sensation	Tumor mass to right of and behind lower part of esophagus and cardia of stomach; mass extends through esophageal hiatus	Obstruction of lower end of esophagus with deviation posteriorly and to left	Intramural leiomyoma	Weight, 140 Gm.; 15 by 7 cm.	Lower part of esophagus extruded through hiatus	Satisfactory
Harper and Tiscenco, 1945	41	M	Epigastric tightness after eating; choking sensation	Filling defect in lower half of esophagus	Mucosa-covered tumor in right lateral wall of esophagus 30 cm. from incisors	Esophageal tumor	.....	Lower portion of esophagus; a tumor on posterolateral wall extending upward posteriorly to the aortic arch	Died
Schafer and Kittle, 1946	46	M	Epigastric distress; nausea; vomiting; anorexia; pain in costovertebral angles	Large mass in lower part of mediastinum; displacement of thoracic area of esophagus to the right; upper 1/5 of stomach within mediastinum	None	Diaphragmatic hernia	.....	Lower end of esophagus 6 cm. above diaphragm	Satisfactory
Calmenson and Clagett, 1946	52	M	Substernal distress	Deviation of middle third of esophagus by a tumor mass; just above this was a similar mass	Two tumors; one at junction of upper and middle thirds, the other in the middle third	Leiomyoma	.....	One tumor just beneath and adjacent to aortic arch; the other lay slightly higher in position	Satisfactory
Goldman, 1948.	63	F	Dysphagia 5 yr.; epigastric distress; tarry stools	Partial obstruction; half-moon smooth filling defect	Pinkish white round tumor shining through thinned-out mucosa	Benign tumor of esophagus	4 by 3.3 by 2.7 cm.	Lower end 1 cm. above esophageal hiatus	Satisfactory
Goldman, 1949.	51	F	Dysphagia 9 mo.; substernal discomfort 9 mo.	Irregularity of lower half of the esophagus; retrocardiac mass	Smooth, pink, mucosa, lumen irregularly distorted; unable to enter stomach	Leiomyoma	10.5 cm.	Lower one half of the esophagus; involved portion of cardia; hiatus hernia	Satisfactory

Harrington and Moersch reported 2 cases in 1944.[17] One patient was a 39 year old man who was first seen because of a history of asthmatic bronchitis and hay fever. A roentgenogram of the chest revealed an increased density in the left side of the inferior-posterior mediastinum. Roentgenograms made after a swallow of barium disclosed the lower end of the esophagus to be deformed and displaced to the left. A diagnosis of diaphragmatic hernia was made, and a thoracotomy was done. At operation the lower 5 inches (12.7 cm.) of the esophagus was found to be surrounded by a lobulated tumor which extended to the cardia. The lower quarter of the esophagus was resected and an esophagogastrostomy performed. The patient died on the fourth postoperative day, of pneumonia. The second case was that of a 56 year old woman who had complained for one month of pain beneath the xiphoid process. The distress occurred at irregular intervals in attacks which lasted five to ten minutes. There was no association with food or swallowing. A roentgenographic examination revealed a tumor mass lying to the right and behind the lower part of the esophagus and cardia of the stomach. This lesion apparently involved the distal portion of the esophagus and extended through the hiatus. Esophagoscopy revealed an obstruction at the lower end due to a growth which involved the wall and pushed the esophagus posteriorly and to the left. The mucous membrane was intact. A preoperative diagnosis of leiomyoma was made. Thoracotomy revealed a large leiomyoma involving the lower portion of the esophagus, which was enucleated. The patient had an uneventful convalescence.

Harper and Tiscenco[18] reported a case in 1945. The patient was a 41 year old man who had been ill for three years. His complaints were those of tightness and a feeling of distention in the epigastrium after meals. Nausea and vomiting were frequent occurrences. His disease was diagnosed as peptic ulcer, and he was placed on an ulcer regimen, without beneficial effect. Esophagoscopy was then done, and a tumor covered by mucosa was found in the right lateral wall of the esophagus about 30 cm. from the incisor teeth. A filling defect in the lower third of the esophagus was visualized in roentgenograms. At thoracotomy a tumor mass was found occupying the posterolateral wall of the esophagus and extending upward posteriorly to the aortic arch. The growth was excised. The patient did well until the fourth postoperative day, when he succumbed from "wet lungs."

17. Harrington, S. W., and Moersch, H. J.: Surgical Treatment and Clinical Manifestation of Benign Tumors of the Esophagus with Report of Seven Cases, J. Thoracic Surg. **13**:394-414, 1944.

18. Harper, R. A. K., and Tiscenco, E.: Benign Tumor of Esophagus and Its Differential Diagnosis, Brit. J. Radiol. **18**:99-107, 1945

Schafer and Kittle [18] in 1946 successfully removed a leiomyoma of the distal end of the esophagus. The patient was a 46 year old man who complained for eighteen months of pain in the right lower region of the chest. He also experienced frequent episodes of nausea and vomiting but no dysphagia. Roentgenograms revealed a large rounded mass in the lower end of the posterior mediastinum suggestive of a diaphragmatic hernia. The lower portion of the esophagus was displaced to the right. The upper one fifth of the stomach lay within the mediastinum. A diagnosis of diaphragmatic hernia was made, and a thoracotomy was done. At operation a leiomyoma of the esophagus measuring 7 by 7 by 10 cm. was found on the left posterolateral wall about 6 cm. above the diaphragm. A major portion of the fundus of the stomach protruded through an enlarged esophageal hiatus. The tumor mass was lobulated and firm. Because of the tumor's griplike relation with the esophagus, it was necessary to excise with it an ovoid portion of the esophageal wall measuring 3 by 7 cm. This defect was closed longitudinally. Convalescence was uneventful.

Calmenson and Clagett [19] in 1946 reported the successful removal of a pair of leiomyomas of the esophagus. The patient was a 52 year old man who had a ten year history of substernal distress, slight dysphagia and epigastric pain. He was treated for peptic ulcer. He experienced no relief with this therapy, and further studies were done. Roentgenograms revealed a compression and deviation of the middle third of the esophageal wall by a mass measuring about 6 cm. in diameter. Just above this growth was a smaller but similar mass. Esophagoscopy visualized two tumors. One was located at the junction of the upper and middle thirds of the esophagus. The other was situated in the middle third of the esophagus. Both tumors were covered by an intact mucosa. A preoperative diagnosis of leiomyoma was made. This was confirmed by thoracotomy, and both tumors were easily enucleated. Convalescence was uneventful.

Harrington [20] recently has summarized his experience with benign and secondarily malignant tumors of the esophagus. He cited 1 case in which there were two large, long-pedicled fibromyomas at the introitus of the esophagus. Seven intramural tumors were leiomyomas, and two were malignant leiomyosarcomas. None of the seven leiomyomas involved the mucous membrane. He described three types according to gross characteristics: completely encapsulated tumors, involving a small segment of the outer esophageal wall; multiple tumors of multicentric origin involving a large segment, and diffuse

19. Calmenson, M., and Clagett, O. T.: Surgical Removal of Leiomyomas of Esophagus, Am. J. Surg. **72**:745-747, 1946.

20. Harrington, S. W.: Surgical Treatment of Benign and Secondarily Malignant Tumors of the Esophagus, Arch. Surg. **58**:646-661 (May) 1949.

tumors which may be termed leiomyomas involving the entire circumference of the outer wall.

Case 1 reported herein fits into the first type described by Harrington,[20] but the second case does not seem to be included in his classification, and it represents a large leiomyoma which had irregularly circumscribed the esophagus in a fistlike grip but without destruction of the mucosa. The tumor described by Schafer and Kittle [18] was similar to that in case 2; it gripped the entire lower part of the esophagus like a fist, there was an asociated gastric hiatus hernia and it was necessary to perform gastric-esophageal resection with primary anastomosis.

REPORT OF CASES

CASE 1.—A. W., a white woman aged 63, entered Cedars of Lebanon Hospital on Jan. 4, 1948. Her chief complaints were dysphagia and tightness about the neck since thyroidectomy in 1943 accompanied with vomiting and with tarry stools for three days six weeks before her entry.

Present Illness.—Thyroidectomy was done in 1943 for a nodular goiter, which was assumed to be the cause of her dysphagia. After this operation the symptoms remained essentially the same, and because of some epigastric distress she was considered probably to have an ulcer and was treated at intervals for nervous disorder of the stomach and ulcer until the present admission. Because of a history of cancer in the family and the dysphagia, she had consulted her family physician. A roentgenogram made of her esophagus after she swallowed barium showed a filling defect in the lower end (fig. 1). As this filling defect was probably malignant, she was referred for further therapy and diagnosis to Dr. Sam Perzik. He rightly was reluctant to administer roentgen ray therapy without a definite microscopic diagnosis. Biopsy of an axillary lymph node did not reveal malignant disease, and the patient was referred for esophagoscopy. On Jan. 5, 1948, esophagoscopy was performed (A.G.). In the lower third of the esophagus there were some changes of the mucosa giving it a bluish tinge, and at the esophageal hiatus the right wall was solid and had the appearance of a tumor bulging into the lumen. By proper manipulation of the esophagoscope, it was possible to telescope the tumor partially into the open distal end of the esophagoscope, and pinkish white tumor could be seen shining through the intact but thinned-out mucosa. Material for a biopsy was taken when it was in this position. Biopsy showed numerous muscle cells and some chronic esophagitis. These muscle cells were actually from the muscular wall of the esophagus and not from the tumor itself. The patient was placed on a high protein, high caloric diet supplemented with 1,000 mg. of ascorbic acid and 100 Gm. of protein hydrolysate daily for ten days. She was admitted to Cedars of Lebanon Hospital for exploratory thoracotomy on Jan. 15, 1948. Physical examination showed a fairly well developed woman with some evidence of loss of weight, looking approximately the stated age. There was one axillary biopsy scar. There were no residual nodules beneath the thyroid or in the surrounding area. The skin and mucous membrane showed some evidence of dryness and poor nutrition. The lungs were clear. The heart sounds were normal. The blood pressure was 130 systolic and 85 diastolic. The weight was approximately 100 pounds (45.4 Kg.). The electrocardiogram was reported to be normal. The abdomen was scaphoid, without masses or tenderness. The reflexes were slightly hyperactive and negative. There was slight tenderness below the xiphoid process just to the left of the midline. No masses could be felt. There was no clubbing of the fingers.

The urine was normal. The red blood cell count was 4,320,000, with a hemoglobin content of 86 per cent, or 13.3 Gm. per hundred cubic centimeters. The white blood cell count was 6,440, with 65 per cent polymorphonuclear cells, 25 per cent lymphocytes and 10 per cent monocytes. The hematocrit value was 35 per cent. Roentgenologic examination of the esophagus again showed the half-moon, smooth filling defect in the lower part of the esophagus (Dr. Eugene Freedman). The diagnosis was probable benign esophageal tumor. This was based on the long history, the smooth outlines of the filling defect in the roentgenograms after a swallow of barium (fig. 1) and the esophagoscopic findings.

Operation.—Exploratory thoracotomy was performed on Jan. 16, 1948 (A.G.). A right, rather than a left, posterolateral approach was used because the tumor mass was discrete and protruded into the right pleura and there was little likelihood of having to mobilize the stomach or to do an esophagogastrostomy. The anesthetic was cyclopropane, intratracheally, thiopental sodium (pentothal sodium®),

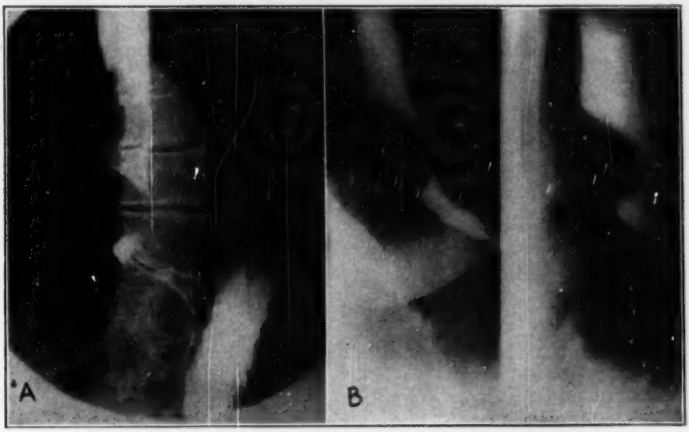


Fig. 1 (case 1).—Roentgenograms made on Dec. 16, 1947. *A*, filling defect of the lower end of esophagus caused by leiomyoma. Note indistinct extramural mass and half-moon-shaped filling defect of esophagus. *B*, spot films showing smooth half-moon-shaped filling defect at the lower end of the esophagus.

nitrogen monoxide and oxygen with curare.[21] After intratracheal intubation, with the patient lying on the left side, a lengthy incision was made in the eighth interspace from the costal cartilages to the transverse process and the pleural cavity was opened.

The inferior mediastinal pleura from just above the esophageal hiatus to the inferior pulmonary vein was tissue paper thin, and bulging through it toward the right pleural cavity was a rounded mass measuring 5 by 4 cm. (fig. 2). It was smooth, slightly bosselated, solid and rubbery. It was pinkish white to ivory and had the gross appearance of a leiomyoma. There were some atrophic fibrous

21. Stephens, H. B.; Haroun, P., and Beckert, F. E.: Curare in Anesthesia for Thoracic Surgery, J. Thoracic Surg. **16**:50-61, 1947.

muscle bands over its surface. As the tumor was lifted up, the esophagus came with it. Some mediastinal adhesions were present to the tip of the lower lobe of the lung, which were severed. There were also numerous bandlike adhesions over the entire anterolateral rim of the right lower lobe to the diaphragm. These were likewise severed by means of sharp dissection to facilitate exposure of the tumor. There were a few small vessels coursing over the sides and surface of the tumor, but bleeding was slight.

With blunt and sharp dissection the muscle bands were separated, until the tumor, as it lay within the esophageal musculature, was dissected free from its bed. With further dissection the tumor came away easily, leaving an oozing surface in the wall of the esophagus. The mucosa was thinned out but not penetrated, and the most adherent area was in the submucosal layer. After removal of the tumor, four interrupted 00005 silk sutures 1.0 cm. apart were used to

Fig. 2 (case 1).—Surgical specimen of leiomyoma of the esophagus.

approximate the musculature of the esophagus and four similar sutures to approximate the mediastinal pleura. The upper part of the esophagus was explored manually, and no lesion was felt. There were no enlarged lymph nodes. The pleura was irrigated with isotonic sodium chloride solution.

The wound was closed with four paracostal doubled no. 1 chromic sutures, interrupted doubled no. 60 cotton sutures for the muscles and fascia layers, single no. 60 cotton sutures for the subcutaneous tissue and black silk for the skin. A no. 26 urethral catheter was placed in the eighth interspace in the midaxillary line for continuous closed drainage of the pleural cavity.

Pathologic gross examination showed an oval smooth tumor with a capsule containing external adherent tags of esophageal muscle tissue (fig. 2). The external surface was glistening pinkish gray white. The cut surface had a whorled pattern with areas of gray white to ivory and pale yellow. The tumor was essentially evascular. Microscopically (figs. 3 and 4) the characteristic struc-

ture consisted of interlacing muscle bundles with elongated cells containing oval or spindle-shaped nuclei. There were a few focal collections of round cells. Van Gieson's stain showed large amounts of fibrous tissue in between the muscle bundles.

The patient was discharged on the eighth postoperative day and has remained well since, without dysphagia and with a normal-appearing esophagram.

CASE 2.—N. C., a white woman aged 51, entered the Cedars of Lebanon Hospital on May 19, 1949, with the chief complaints of mild dysphagia and substernal

Fig. 3 (case 1).—Low power photomicrograph (× 150) showing muscle cells and collagen fibers arranged in interlacing bundles and whorls. Leiomyoma of esophagus.

discomfort. The onset was ascribed to an accident which occurred in October 1948 during which she sustained, while aboard a motor boat, fractures of the pelvis and spine and contusions about the chest and arms. During the twelve weeks of immobilization of her pelvis, she had frequent vomiting, which was ascribed at first to her injuries. Finally, when her condition permitted, roentgenograms disclosed the peculiar irregularity of the lower half of the esophagus

(fig. 5). Her dysphagia consisted of a feeling of food stopping halfway down the chest, and this was accompanied with indefinite midsternal pain. After her recovery from the injury she did not feel as if she had regained her strength or as if she were well. In addition to these injuries her past history showed that she had had chronic cystitis and that the capacity of the bladder was small.

Physical examination showed a tall, slender, fairly well nourished and well developed woman. The skin and mucous membrane were somewhat pale. There was a well healed thyroidectomy scar. There was no clubbing, and no lymph-

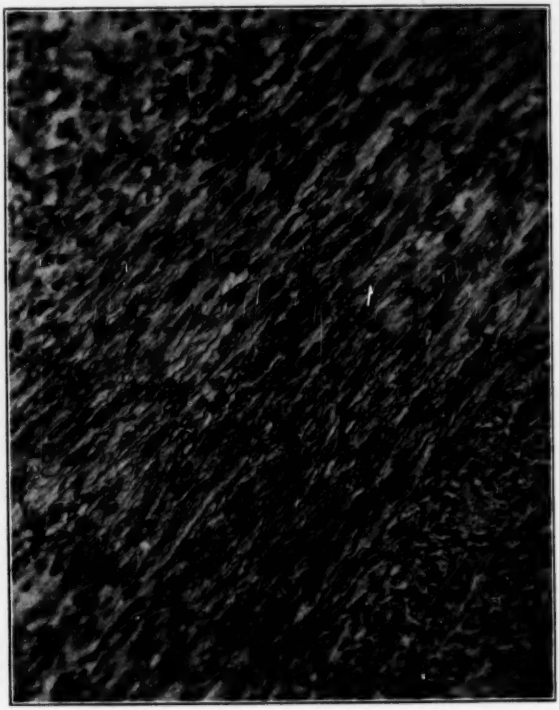


Fig. 4 (case 1).—High power photomicrograph (× 300) showing elongated spindle cells in mature adult muscle.

adenopathy. There was definite lagging of the left side of the chest, and moderate pectus excavatum was observed. The lungs were clear throughout, and the breath sounds were diminished on the left. The heart border was displaced to the left. The heart sounds were regular and rhythmic and there were no murmurs. The blood pressure was 130 systolic and 80 diastolic. The abdomen showed two scars from previous hysterectomy and appendectomy. The hemoglobin content was 10.1 Gm., the red blood cell count 3,650,000, and the white blood cell count

10,280, with 70 per cent polymorphonuclear cells and 30 per cent monocytes. The urine was slightly turbid, with a specific gravity of 1.020, a 1 plus reaction for albumin and a negative reaction for sugar; the sediment showed numerous white blood cells and a moderate number of red blood cells.

Esophagoscopy performed on May 19, 1949 (A. G.) showed the upper two thirds of the esophagus to be slightly dilated, with redundant mucosa and an irregular narrowing of the lower third, but everywhere the esophagus was intact. Gastric mucosa was encountered, but it was not possible to put the esophagoscope entirely into the stomach as there was a marked stricture at the esophageal cardiac junction. Review of the previous roentgenograms made after a swallow of

Fig. 5 (case 2).—Preoperative roentgenogram of the chest after barium was given. Left lateral view showing irregular defect of the lower half of the esophagus. Note the dense shadow in the retrocardiac space. The hiatus hernia was not demonstrated in any of the roentgenograms of the chest because the stomach was a free-sliding hernia and the tumor mass prevented the cardia from filling.

barium and reexamination showed the irregularity of the lower half of the esophagus apparently unchanged over a period of observation of nine months. It was therefore felt that this was not a malignant tumor, but since the mucosa was not involved the preoperative diagnosis of leiomyoma was made. The patient was prepared for operation and given 1,500 cc. of blood preoperatively and a large amount of protein and vitamins as well as penicillin and sulfadiazine for her cystitis.

Operation was performed on May 24, 1949 (A. G.) A left posterior lateral approach was made and the eighth rib subperiosteally resected. A large bulging tumor was found in the posterior mediastinum. Two thirds of the stomach herni-

ated through the markedly enlarged hiatus into the posterior mediastinum. The mass was intimately adherent to the stomach and seemed to arise from it. It completely surrounded the esophagus and was partially covered by longitudinal musculature of the esophagus. The tissues around it were moderately vascular. The griplike mass was so intimately adherent to the mucosa which ran through it that the leiomyoma could not be separated without tearing through the mucosa; therefore it was necessary to perform a resection of the lower 4 inches (10.16 cm.) of the esophagus and a portion of the cardia of the stomach in order to remove the tumor safely. Because of herniation, mobilization of the stomach was relatively nonextensive, and in general the technic described by Garlock [22] for resection of the esophagus was carried out. The proximal end of the esophagus was implanted into a separate opening in the anterior wall of the cardiac portion of the stomach, a superior portion of the stomach being left above the esophageal entrance. The phrenic nerve was pinched, and the stomach was sutured to the

Fig. 6 (case 2).—Surgical specimen showing the esophagus compressed by the tumor mass. Note the adherent gastric mucosa on the left hand edge.

enlarged hiatal ring after the omentum was brought over the anastomotic suture line. Approximately one half of the stomach was left in the intrathoracic area. Silk was used throughout this procedure. Closed tube drainage of the pleural cavity was instituted. The patient had an uneventful recovery except that the cystitis flared up and required catheter drainage. A swallow of barium showed no delay at the diaphragm or the cardiac esophageal junction on the fourteenth day, the time of discharge.

The operative specimen was an irregular spherical mass 10.5 cm. in diameter (fig. 6). The external surfaces showed yellow-tan areas and an attached strip of gastric mucosa 6 by 5 cm. Approximately 3 inches (7.6 cm.) of mucous mem-

22. Garlock, J. H.: The Surgical Treatment of Carcinoma of the Thoracic Esophagus, Surg., Gynec. & Obst. **70**:556-569, 1940.

brane of the esophagus was encompassed by the tumor. Microscopic examination (fig. 7) showed bundles of interlacing smooth muscle cells with a moderate amount of fibrosis and edema. The smooth muscle cells were uniform, and there was no mitotic activity or evidence of malignancy. The diagnosis was leiomyoma of the esophagus.

Follow-up on July 20, 1949, approximately two months after the operation, showed the patient to have regained her weight and strength. She was able to

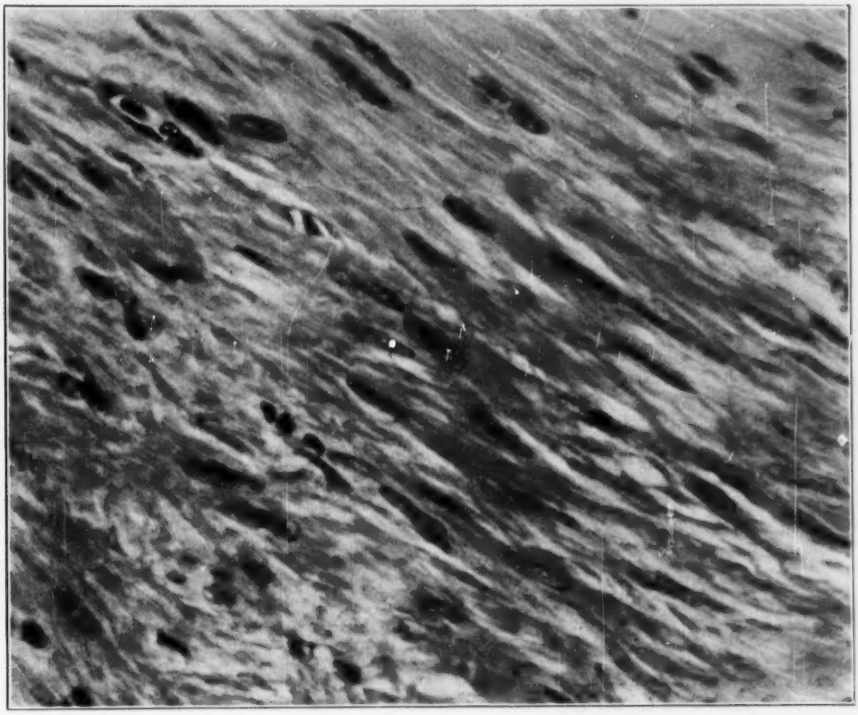


Fig. 7 (case 2).—Photomicrograph (× 500) showing elongated spindle cells characteristic of leiomyoma.

eat solid food without any difficulty. A roentgenogram made after a swallow of barium showed a slight delay at the level of the diaphragm.

DIAGNOSIS

Leiomyomas of the esophagus are uncommon and are frequently not considered when a tumor of the esophagus is being investigated. Of the cases herein reported, in only 3 was a preoperative diagnosis of leiomyoma considered. It is realized that other benign tumors can

simulate leiomyoma so closely that the clinical diagnosis without positive histologic confirmation can only be surmised. Failure to use the esophagoscope and the misinterpretation of roentgenologic findings lead to errors in diagnosis. Often the patient has been treated for peptic ulcer, diaphragmatic hernia, malignant growth, cardiac angina, dyspepsia or hyperthyroidism. The esophagoscopic examination gives positive differential aid. A leiomyoma of the esophagus usually manifests itself as an extramucosal tumor which pushes into the esophageal lumen. The presence of an intact mucosa above the tumor is the common finding because leiomyomas are noninvasive, circumscribed tumors of the muscular layers and not of the mucosa. However, Kenworthy and Welch [23] recently reported on a successfully resected leiomyoma which was intraluminal and involved the cardia of the stomach with the lower end of the esophagus. As in Melnick's [24] case of gastric leiomyoma, the gastric portion was ulcerated. Epidermoid carcinoma arises in the mucosa and frequently produces ulceration. However, occasionally obstructing malignant lesions of the esophagus are present intramurally and extramurally without mucosal ulceration. Removal of uninvaded mucosa through the esophagoscope for biopsy is dangerous but may be of great value in ruling out the presence of a malignant tumor.

Leiomyomas of the esophagus frequently produce no symptoms and are eventually discovered only as incidental findings at autopsy or on roentgen study. Symptoms occur when the tumor obstructs the esophagus and produces reflex vomiting, cardiospasm or pain associated with malignant change. This happens only rarely. Rose,[6] in reviewing 49 autopsies, found the tumor most often in the distal third of the esophagus and noted that in only 4 of the cases had the patients complained of any distress. It is usually as a result of mechanical pressure that distress occurs. It is necessary, therefore, to examine carefully the lower third of the esophagus roentgenographically in all patients with dysphagia or with bizarre symptoms in the upper abdominal area in order to find occult cases. Multiple myomas [10] of the esophagus have been described, and association with diverticulum [25] and hiatus hernia has also been noted.[17] The presence of thyroid disease which led to previous thyroidectomy is of interest (cases 1 and 2).

In a consideration of the differential diagnosis, other conditions producing rounded masses with filling defects of the esophagus in the

23. Kenworthy, R. A., and Welch C. S.: Leiomyoma of the Esophagus and Cardia of the Stomach, Surgery **23**:745-752, 1948.

24. Melnick, P. J.: Metastasizing Leiomyoma of the Stomach, Am. J. Cancer **16**:890-899, 1932.

25. Stewart, J. D., Jr.: Myoma of Esophagus with Associated Diverticula, Arch. Path. **12**:77-84 (July) 1931.

anterior pleuromediastinal or inferior mediastinal spaces may simulate a leiomyoma of the esophagus. The following conditions not arising in the esophagus may give roentgenologic signs which are confused with those of leiomyoma or other benign tumors of the esophagus: aneurysm of the descending aorta, neurofibroma of the mediastinum, strangulating diaphragmatic hernia of the liver,[26] granuloma of the mediastinum,[27] carcinoma of the stem bronchus, usually the right, posterior undifferentiated mediastinal tumors, mediastinal lymphoma, benign esophageal strictures often associated with chronic peptic ulceration of the esophagus [28] and esophageal diverticulum.

PATHOLOGIC AND ROENTGENOLOGIC CONSIDERATIONS

It is difficult to distinguish, grossly or microscopically, leiomyoma, fibroma, myoma, fibromyoma and myofibroma. Most pathologists probably designate such tumors according to the predominance of muscle, fibrous tissue or smooth muscle. Such a designation is biased by the particular section of tumor examined, and besides it is probable that pathologists would differ in their interpretation of the same sections. All tumors of this group are never composed entirely of smooth muscle, but if they are located within the muscular wall of the esophagus and large amounts of smooth muscle cells are present, this is sufficient to assume the origin to be from smooth muscle and to designate the tumor as a leiomyoma. Rarely malignant transformation from these benign tumors may occur.[29] The noninvasive smooth surface gives rise to the smooth, often half-moon-shaped, filling defect seen in roentgenograms after a swallow of barium (fig. 1). The irregularity of the griplike form may simulate malignant tumors, and the large ones may present roentgenologic demonstration of the associated hiatus hernia (fig. 5).

SURGICAL CONSIDERATIONS

In the consideration of what side the tumor should be approached from, two questions are important: (1) Into which pleural cavity does the tumor bulge? (2) Will mobilization of the stomach with esophageal resection, esophagogastrostomy or repair of an associated diverticulum, cardiospasm or diaphragmatic hernia be necessary? (table 2). The left approach is determined by the preoperative presence of any condition which may require mobilization of the stomach. Either the right or the left approach can be used in the absence of such a condition

26. Wolfson, S. A., and Goldman, A.: Strangulating Diaphragmatic Hernia of the Liver, Surgery **24**:846-852, 1948.

27. Goldman, A.: Personal observation.

28. Morton, D. R., and Brunschwig, A.: Peptic Ulcer of Esophagus: Report of Patient with Ten Year Follow-Up, Gastroenterology **7**:314-319, 1946.

29. French, L. R., and Garland, L. H.: Leiomyosarcoma of the Esophagus, Am. J. Roentgenol. **45**:27-31, 1941. Melnick.[24]

according to the side on which the tumor predominates. Whenever the tumor presents an extensive griplike relation with the esophagus or involves the cardia, we prefer to approach it always from the left because an esophageal resection may be necessary (case 2). Ideally, it is best to enucleate the tumor without penetrating the mucosa (case 1). However, occasionally the tumor is so adherent to the mucosa that opening into the esophageal lumen cannot be avoided. Careful closure of this rent with interrupted silk sutures should be done in such instances. It may be necessary to resect a portion of the esophagus because of the large size of the tumor or its intimate relation with the mucosa.

TABLE 2.—*Results of Resection of Leiomyomas According to Procedure Used*

Author	Approach	Procedure	Result
Ohsawa	.....	Enucleation	Satisfactory
Harrington and Moersch	Left thoracotomy; 8th rib resected	Resection of distal ¼ of esophagus and cardia of stomach, esophagogastrostomy	Died
Harrington and Moersch	Abdominal; upper left rectus incision	Enucleation	Satisfactory
Harper and Tiscenco	.....	.....	Died
Schafer and Kittle	Left thoracotomy; resection of 9th rib	Excision of tumor with portion of esophageal wall	Satisfactory
Calmenson and Clagett	Left thoracotomy; 5th rib resected	Enucleation	Satisfactory
Goldman	Right thoracotomy	Enucleation	Satisfactory
Goldman	Left thoracotomy	Esophageal resection; resection of the distal ¼ of esophagus and cardia of stomach	Satisfactory

SUMMARY

Leiomyomas of the esophagus can be successfully removed and an assurance of cure given. Errors in diagnosis are not uncommon but can reasonably be avoided by the skilful use of roentgenograms and the esophagoscope. Leiomyoma of the esophagus is not common, but it must be considered in the evaluation of any esophageal tumor which has an associated smooth esophageal filling defect or an irregularity not involving the mucosa on roentgen examination with barium, especially if it is located in the distal portion.

Enucleation of the growth without entering the esophageal lumen is the desired procedure. Occasionally, however, these tumors surrounding the esophagus in griplike fashion may require esophageal resection for adequate removal of the leiomyoma. The operative approach is best determined by the position of the tumor and whether gastric mobilization is required. A right approach was adequate in case 1 and a left approach in case 2.

A review of the literature is given, and two additional reports of successful removal of esophageal leiomyomas are presented.

9884 Santa Monica Boulevard.

STUDIES OF RABBIT ORGANS AFTER INTRAVENOUS INJECTIONS OF PECTIN SOLS

CARROL S. SMALL, M.D.
LOMA LINDA, CALIF.
EDWIN F. BRYANT, Ph.D.
AND
GRANT H. PALMER, B.A.
CORONA, CALIF.

THE NEED for a substitute for blood has been recognized for some time. Many substitutes for whole blood have been proposed for use in the treatment of shock, nephrosis and other diseases for which transfusions are indicated. Early experience with whole blood revealed that it was necessary to cross match the blood of the donor with that of the recipient. This inconvenience, together with that of finding suitable donors at the time of the emergency requiring the need of a transfusion, led to the search for substitutes or a method for storing typed blood. A further point in favor of substitutes for blood is the high cost of treatment with blood or plasma as well as the frequent incidence of jaundice noted after the use of plasma during the war.

Citrated whole blood has been used widely for many years and still remains a desirable means of transfusion in certain cases; it has, however, a poor storage life. Liquid plasma is only slightly more stable, whereas dried plasma can be stored indefinitely. The preparation of dried plasma is expensive, and massive transfusion treatment by this means is almost financially prohibitive. For these reasons several substitutes for plasma have been proposed. Pectin is one of those suggested.

The use of isotonic pectin sols as a substitute for plasma has been studied by many workers [1] using solutions prepared by different pro-

Dr. Small is Associate Professor of Pathology, College of Medical Evangelists, Loma Linda, Calif., and Dr. Bryant and Mr. Palmer are from the research department, California Fruit Growers Exchange, Corona, Calif.

1. (*a*) Hartman, F. W.; Schelling, V.; Harkins, H. N., and Bush, B.: Pectin Solution As a Blood Substitute, Ann. Surg. **114**:212-225 (Aug.) 1941. (*b*) Hartman, F. W.; Schelling, V.; Bush, B., and Warren, K. W.: The Relative Value of Pectin Solution in Shock, J. A. M. A. **121**:1337-1341 (April 24) 1943. (*c*) Hueper, W. C.: Experimental Studies in Cardiovascular Pathology; VI. Pectin Atheromatosis and Thesaurosis in Rabbits and in Dogs, Arch. Path.

(Footnote continued on next page)

cedures. Hartman and others [1a,b] have advocated a concentration of 0.75 to 1.5 per cent pectin. They prefer the 0.75 per cent pectin sol made by heating for fifteen to eighteen hours in an Arnold sterilizer and filtering three times during this period. They adjust the p_H to 7 by adding a phosphate buffer just before intravenous use. Hueper [1c] studied the effectiveness of pectin sols, using autoclaved and unautoclaved 1.2 per cent pectin sols which he buffered to p_H 6.5 to 7.0 with "lime water or phosphate buffer solution." Kozoll,[1d,e] Meyer,[1f] and Popper [1g] used a 1.5 per cent pectin sol buffered to about p_H 7.2 with phosphate or lactate.[2] Figueroa and Lavieri [1h] used a 1 per cent pectin sol buffered to p_H 6.0 to 6.5 with a 5 per cent solution of disodium acid phosphate. Jacobson and Smyth [1i] used a 0.75 per cent pectin sol furnished by Dr. F. W. Hartman. In our earlier work we [1j] used an autoclaved unbuffered 6 per cent pectin sol.

Clinical studies [3] showed that autoclaved buffered pectin sols give favorable results in the treatment of patients in shock as well as patients not in shock.

Hueper [1c] and Popper and others [1g] observed pathologic changes in the tissues of animals and human beings after the intravenous administration of massive amounts of pectin sols. However, chemical analyses failed to show any appreciable amounts of pectin retained in the affected organs.[1e,j]

34:883-901 (Nov.) 1942. (*d*) Kozoll, D. D.; Steigmann, F., and Popper, H.: Studies of Pectin Administration to Patients Not in Shock, Soc. Exper. Biol. & Med. **53**:66-67 (May) 1943. (*e*) Kozoll, D. D.; Volk, B. W.; Steigmann, F., and Popper, H.: Pectin Excretion Studies in the Human Being, J. Lab. & Clin. Med. **31**:30-39 (Jan.) 1946. (*f*) Meyer, K.; Kozoll, D. D.; Popper, H., and Steigmann, F.: Pectin Solutions in the Treatment of Shock, Surg., Gynec. & Obst. **78**:327-332 (March) 1944. (*g*) Popper, H.; Volk, B. W.; Meyer, K. A.; Kozoll, D. D., and Steigmann, F.: Evaluation of Gelatin and Pectin Solutions as Substitutes for Plasma in the Treatment of Shock, Arch. Surg. **50**:34-45 (Jan.) 1945. (*h*) Figueroa, L., and Lavieri, F. J.: The Use of Pectin and Other Agents to Prevent Shock, Surg., Gynec. & Obst. **78**:600-605 (June) 1944. (*i*) Jacobson, S. D., and Smyth, C. J.: Plasma Volume Changes Following the Intravenous Injection of Pectin and Physiologic Saline in Man, Proc. Soc. Exper. Biol. & Med. **50**:218-220 (June) 1942. (*j*) Bryant, E. F.; Palmer, G. H., and Joseph, G. H.: Non-Accumulation of Pectin Intravenously Injected into Rabbits, Soc. Exper. Biol. & Med. **49**:279-282 (Feb.) 1942. (*k*) Middleton, S., and Wigger, C. J.: Some Effects of Pectin Solutions During Post-Hemorrhagic Hypotension, Am. J. Physiol. **140**:326-333, 1943.

2. The phosphate buffer is a 5 or 10 per cent solution of disodium acid phosphate. The lactate buffer consists of a mixture of glycine, sodium lactate and sodium hydroxide.

3. Hartman and others.[1a,b] Kozoll and others.[1d,e] Meyer and others.[1f] Popper and others.[1g] Figueroa and Lavieri.[1h]

Many lesions were noted by Hueper in all rabbits given the unautoclaved buffered pectin sol. However, when he used an autoclaved buffered pectin sol, he observed a few lesions in just 1 of the 6 rabbits so treated.

The purpose of the present paper is to discuss the effect on rabbit tissues of massive volumes of intravenously injected pectin sols. The pectin sols were prepared to contain 1.5 per cent pectin N. F. dispersed in isotonic sodium chloride solution. The sols were autoclaved at 15 pounds pressure (250 F.) for thirty minutes and were filtered sparkling clear. They were administered with and without added buffer. The apparent molecular weight of the pectin in the sols used was between 35,000 and 45,000.

Comparisons of the weight of the heart, kidneys, liver, lungs and spleen are given, and histopathologic tissue studies were made of the kidney, liver and spleen of each rabbit. These experiments were extensive enough to determine whether the pathologic changes noted by Hueper and Popper are permanent or transitory as intimated by Popper. The tissues were also studied histologically when stained with ruthenium red before and after treatment with ammonium oxalate.

Ruthenium red, although primarily a stain for pectic material in plant tissues, as discussed by Branfoot [4] and Norman,[5] has been used in histologic studies of human and animal tissues of subjects previously treated intravenously with pectin sols.[1c,g] The use of ruthenium red necessitates the use of pectic-dissolving agents to differentiate the pectic substances staining with ruthenium red. In the present study 0.5 per cent ammonium oxalate in 3 per cent ammonia was used to dissolve the pectic material, as suggested by Mehta.[5]

PART I. TREATMENT OF THE RABBITS

Pectin sols were injected into the marginal ear vein of rabbits of both sexes ranging in weight at the start of treatment from 1.28 to 2.15 Kg. The 36 rabbits used in this study were New Zealand Whites and Himalayans raised in the vicinity of Corona, Calif., on Albers whole family ration.

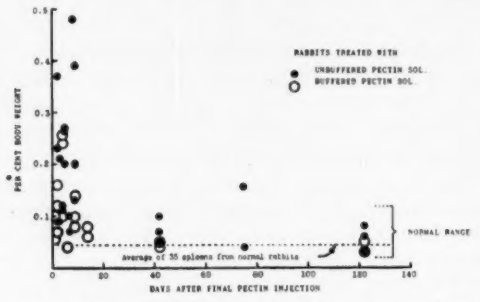
Two groups of rabbits were given injections of autoclaved pectin sols. One group (15 rabbits) was given unbuffered autoclaved 1.5 per cent pectin sols (p_H 3.7 to 3.9), and the other group (18 rabbits) was given buffered autoclaved 1.5 per cent pectin sols (p_H 6.0 to 7.5). The sols

4. Branfoot, M. H.: A Critical and Historical Study of Pectic Substances of Plants, Food Investigation, Special Report Series, no. 33, London, His Majesty's Stationary Office, 1929.

5. Norman, A. G.: The Biochemistry of Cellulose, Polyuronides, Lignin, etc., Oxford, Clarendon Press, 1937.

were buffered with the sodium lactate mixture just before being used. Three rabbits were used as controls. Each rabbit receiving pectin was given a total of 100 cc. of the pectin sol per kilogram of original body weight in doses of 30 cc. per day. On completion of the injections the animals were killed at intervals varying from one to one hundred and twenty-two days after the last injection, i. e., one, two, four, five, six, nine, fourteen, forty-two and one hundred and twenty-two days.

A summary of the weights of the various organs in terms of the per cent of body weight at the time the animal was killed in relation to the p_H of the pectin sol injected and the time interval after the last injection is given in the accompanying table. The chart gives the weight of the



Change in weight of rabbit spleens following injection of pectin.

TABLE 1.—*Summary of Data in Relation to p_H of Pectin Sol*

Pectin Sol p_H	Days After Last Injection	Number of Rabbits in Group	Per Cent of Body Weight				
			Liver	Kidneys	Spleen	Heart	Lungs
Controls.....	...	3	3.86	0.56	0.03	0.35	0.47
3.7 to 3.9.....	2	3	3.02	0.73	0.23	0.36	0.55
	5	3	3.64	0.81	0.24	0.29	0.64
	9	3	2.76	0.68	0.24	0.27	0.56
	42	3	3.88	0.61	0.07	0.25	0.35
	122	3	3.05	0.54	0.06	0.19	0.27
6.0 to 7.5.....	1	2	3.19	0.67	0.07	0.26	0.52
	2	3	3.16	0.65	0.12	0.26	0.41
	4	3	3.53	0.60	0.19	0.26	0.40
	6	1	3.55	0.67	0.04	0.32	0.45
	9	3	3.24	1.01	0.11	0.29	0.46
	14	2	4.53	0.65	0.07	0.31	0.52
	42	2	4.84	0.61	0.05	0.23	0.46
	122	2	2.61	0.55	0.04	0.22	0.33
Normal.....	Previous data	As shown	3.35(13)	0.59(12)	0.05(35)	0.25(9)	....
	Skelton *	Not given	5.2	0.71	0.10	0.88	1.24

* Data are from "The Storage of Water by Various Tissues of the Body" by H. Skelton, Arch. Int. Med. **40**: 140-52, 1927, cited on page 904 in Macleod's "Physiology in Modern Medicine," ed. 8, St. Louis, C. V. Mosby Co., 1938.

spleens following injection of pectin. It includes the spleens of the rabbits reported on in the present study as well as those of 9 rabbits previously studied by us.

PART II. HISTOPATHOLOGIC STUDIES OF TISSUE

The organs obtained at autopsy were embedded in paraffin, and several sections of each organ were cut 8 microns thick.

The discussion of the microscopic examination of the tissue sections will be considered under two headings: (*A*) routine staining with hematoxylin-eosin and (*B*) special staining with ruthenium red. Section B will be further broken down to consider the tissue sections before and after treatment with ammonium oxalate.[6]

Section A. Hematoxylin-Eosin.—When unbuffered pectin sols were used, pathologic lesions were noted in the spleens of all animals autopsied within nine days after the last injection of pectin. These were similar to the splenic lesions noted by Hueper[1c] and by Popper.[1g] The spleens showed many giant cells and some fibrosis. Five of the 18 animals treated with pectin sols buffered to a p_H of 6.0 to 7.5 had lesions of the spleen. However, the lesions were not as pronounced as those seen in the unbuffered group and appeared only in animals autopsied during the first four days after the final injection of pectin.

Renal lesions were observed in 2 of the animals treated with the unbuffered pectin sols. These lesions were similar to those described by Hueper,[1c] with the exception that no swollen glomerular endothelial cells were seen. The kidneys of the animals treated with the buffered pectin sols were normal.

One animal of each treated group had a slight periportal lymphocyte infiltration, which was more pronounced in the animal receiving the unbuffered pectin sol. The hepatic lesions described by Hueper[1c] and by Popper[1g] were not found in these tissues.

The lesions caused by treatment with pectin sol appeared to be transitory, as they were not seen beyond the ninth day after the last injection of unbuffered pectin sol or beyond the fourth day after the last injection of buffered pectin sol and did not recur in one hundred and twenty-two days, when the study ended.

Section B. Ruthenium Red.—Duplicate slides of the tissues were studied after they were stained with ruthenium red. The ruthenium red solution was prepared by adding 6.2 mg. of the ruthenium salt to 20 cc. of carbon dioxide–free distilled water, which was shaken occasionally while standing at room temperature for two to three hours. It was then

6. Detailed tables describing the microscopic examination of these tissues have been omitted from this manuscript because of their space requirement. Investigators interested may secure copies of these tables from the authors.

centrifuged at 2,000 revolutions per minute for fifteen minutes. It was found by experiments on solubility that different lots of ruthenium red contain varying amounts of insoluble material. Since the salt we used contained 35.5 per cent insoluble material, the supernatant fluid of the mixture described is approximately a 1:5,000 solution of ruthenium red. This is the solution which was used to stain the sectioned animal tissues after they had been hydrated and buffered to p_H 7.0.

Further studies of duplicate tissue sections were made by treating them with ammonium oxalate before staining with ruthenium red. After the tissues had been treated for forty-eight hours in ammonium oxalate they were washed in carbon dioxide–free water, placed in a buffer with a p_H of 7.0, stained, dehydrated and mounted in the usual manner.

To determine if the treatment with ammonium oxalate was necessary to dissolve the amorphous deposits in the tissues, sections of the kidneys, liver and spleen from 3 rabbits were soaked in carbon dioxide–free water for sixty-five hours before they were stained with ruthenium red. Microscopic examination of these tissues showed them to be the same as the control tissues which had some red-stained material in the pulp of the spleen.

In a comparison of tissues stained with hematoxylin and eosin and the tissues stained with ruthenium red it was noted that eight of the tissues showing lesions when stained with hematoxylin and eosin did not contain any foreign material which would stain with ruthenium red. On the other hand, there were thirteen tissues stained with ruthenium red that did not show any lesions when hematoxylin-eosin stain was used. It was also found that the treatment with ammonium oxalate partially removed the material from the tissues which were originally stained with ruthenium red.

An example of the picture shown by the tissues more intensely stained with ruthenium red and not treated with ammonium oxalate is as follows for 3 rabbits receiving the unbuffered pectin sol:

Rabbit No. 114: The glomeruli of the kidney contained small red-stained plugs of hyaline-appearing homogeneous material in the capillary loops and in Bowman's spaces. No other abnormality was seen. The splenic pulp showed large branching sheets and masses of red-stained material in the sinuses. Some similar material was seen in the cytoplasm of giant cells in the pulp.

Rabbit No. 115: The glomeruli contained irregular tubelike plugs of red-stained material in the capillary loops and in Bowman's spaces. The spleen showed irregular sheets of red-stained material in the sinuses of the pulp. None was seen in the giant cells.

Rabbit No. 116: The glomeruli showed many red-stained plugs in the capillary loops. In the spleen almost every available crevice of the pulp was filled by red-stained material. None was seen in the giant cells.

The data reveal that staining with ruthenium red showed deposits of foreign material in the livers of 4 animals and in the kidneys and spleens of 8 animals treated with autoclaved unbuffered pectin sols. The four liver sections and six of the kidney sections showed material stained with ruthenium red, which was not evident by the hematoxylin-eosin method. However, the abnormalities of the spleens noted after staining with ruthenium red were seen in all but 1 animal when hematoxylin-eosin stain was used.

The group of animals treated with the autoclave buffered 1.5 per cent pectin sol gives a different picture from that just noted. No foreign material was found in the kidneys or liver, but four spleens were stained with ruthenium red, three of which also showed abnormalities in the hematoxylin-eosin-stained tissue sections.

These experiments indicate that rabbits treated with autoclaved unbuffered 1.5 per cent pectin sols are subject to a deposit of foreign material in the kidneys and spleen. This foreign material stains with ruthenium red and may be removed completely or partially by treatment with ammonium oxalate. Whether or not the material deposited and the lesions seen in the kidney are enough to impair its normal function was not determined. The material deposited in the spleens was sufficient to cause temporary splenomegaly (see chart).

Previous analytic work on human organs [1e] after massive (7 to 9 liters) intravenous injections of pectin sol failed to reveal any appreciable amount of pectic material present in the kidneys or spleen, even in organs which showed foreign material that stained with ruthenium red. We believe that this deposit may have been an acid-insoluble pectic substance and therefore was not extracted from the tissue in the slurry used for analysis. However, since in our animals these deposits soon disappeared it is possible that they are disintegrated by the natural enzymes of the tissue.

It is of interest to note that in no case in which buffered pectin was used were deposits present that could be stained with ruthenium red in any organ of the animals killed later than the fourth day after the final injection of pectin, whereas the treatment with unbuffered pectin caused ruthenium red–stained deposits in all but 3 animals of that group.

SUMMARY

The effects of massive volumes of intravenously injected 1.5 per cent autoclaved pectin sols, buffered and unbuffered, on rabbit organs have been studied. The pectin sols were administered daily in 30 cc. portions until a total of 100 cc. per kilogram of body weight had been given to each animal.

Unbuffered pectin sols (p_H 3.7 to 3.9) were given to one group of 15 animals. Pectin sols buffered with sodium lactate mixture (p_H 6.0 to 7.5) were given to a second group of 18 animals. Two or 3 animals from each group were killed at intervals varying from one to one hundred and twenty-two days after the final injection of pectin.

The weights of the livers, kidneys, spleens, hearts and lungs were recorded for the treated animals. A new set of values for the average per cent of the body weight for these organs from normal rabbits is given.

Tissue sections of the kidney, liver and spleen of each animal were examined for lesions and pectic deposits.

The splenomegaly and lesions caused by administration of pectin sol were transitory and were not present in any animal treated with the buffered pectin sol and autopsied later than four days after the final injection. However, they did persist slightly longer in the animals treated with the unbuffered pectin sols.

PLASTIC SURGERY IN THE UNITED STATES

A Review of the 1948 Literature

GORDON S. LETTERMAN, M.D.
AND
WILLIAM CAREY MELOY, M.D.
WASHINGTON, D. C.

THE ESTABLISHMENT of two journals devoted solely to plastic surgery and the numerous recent papers on the subject give ample evidence of the medical profession's rapidly growing interest in this surgical specialty. Letterman and Brown reviewed eighty-four articles which appeared on plastic surgery of the face in 1947. A survey of general plastic surgery for the same period and by the same writers included over one hundred and sixty-five papers. This is in marked contrast to the some twenty-five articles which Aufricht found on reconstructive surgery in 1910 and 1920.

This is a review of papers on plastic surgery published in the United States during 1948. It provides a brief and fairly comprehensive survey of articles from local, county and state publications which are of limited geographic and numerical circulation. It includes those papers appearing in the more widely distributed surgical journals. The review is offered in hope that it may further ease the task of the physician and student in following the American literature.

CLEFT LIP AND CLEFT PALATE

Blair, who was singularly honored this year by the American Society of Plastic and Reconstructive Surgery, elaborates on certain facts pertinent to cleft lip closure. The margin between success and failure is small. The repair is always visible; "ironically, it is the poor results that attract attention while the factor of an excellent outcome must content himself with the silent flattery of non-recognition."

To obtain free breathing, a symmetric lip and a natural-appearing nose without suture marks or prominent scars is the aim of the surgical procedure. Faulty planning and execution may result in asymmetry of the lip or vermilion, transverse shortening, vertical overlength or vestibular distortions.

From the Department of Surgery, George Washington University School of Medicine.

Generally, the earlier the lip is closed the simpler it is to do it. If it is not accomplished in the first few days of life, any time within the next two years will suffice. When unrepaired, a pronounced droop of the lip can develop, and increased backward displacement of the ala ensues.

The principles of harelip repair were well delineated in the first half of the nineteenth century but almost completely neglected during the following seventy-five years. Two general plans for closing a cleft lip are available today. There are many modifications of each. The Husson-Rose plan eliminates the straight or convex cleft lip borders by curved incisions. When the edges are approximated, the lip is pushed upward and downward. The distance, of course, depends on the depth of the excision, but a long lip is too often the result. Mirault's plan utilizes a flap obtained from one side, turned across the defect and united to the opposite freshened border.

Double cleft lips may be closed on the basis of these two plans. A second operation to lengthen the columella is usually necessary. A superficial trifoil flap obtained from the upper lip is used to advance the nasal tip and enters into the formation of a new columella.

Brown and McDowell, in their paper on the surgical repair of cleft lips, point out that the two advances in recent years are the development of a method of marking which gives symmetric or near symmetric nostrils and the recognition of the importance of a smooth lip border which projects out in front of the lower lip. A brief history of the designs used for repair is provided. The writers' technic is described. Double cleft lips, secondary operations, lower lip flaps and cartilage transplants to the nose are discussed.

Fogh-Andersen gives a brief historical account of the Stein-Estlander-Abbe operation. A Danish surgeon, Professor Stein, in 1848 repaired a defect of the lower lip by rotating a flap from the upper lip. The illustrations from the original article are presented. Estlander, a Finnish surgeon, in 1865 repaired a lip defect by using a cross lip flap. He published this procedure in Germany in 1872 and in France in 1877. The American surgeon, Abbe, in 1898 apparently was the first to use the rotation flap to balance the lips as a secondary cleft lip procedure.

Kitlowski outlines the preoperative and postoperative care of patients with cleft lips and cleft palates. The infant's general condition is of prime importance in determining the time of repair. The reconstruction of the lip should be carried out as soon after birth as possible. The closure is, however, never an emergency procedure. The baby may be adequately fed by syringe or nipple. Ordinarily, the birth weight is regained in about ten days. Three of 4 newborn infants are low in prothrombin. Fortunately, vitamin K therapy is specific in such cases.

Patients are not given roentgen examination to determine the presence of an enlarged thymus. Radiation therapy is dangerous, and pulmonary fibrosis is a definite hazard. The cleft lip is usually repaired between the third and fifth weeks. After operation arm cuffs prevent the child from putting his hands into the mouth. Healing seems most satisfactory when the lip is kept dry and exposed to the air. After four weeks daily gentle massage helps to soften the firm suture line. The cleft palate is not repaired until the patient is at least 1 year old. All palates should be closed before the child reaches the age when he might be expected to start talking. A two stage procedure is carried out when the cleft involves the alveolar process. Tonsils and adenoids are removed before operation if diseased or enlarged. Wind and blowing toys are advocated a month after closure. The mother must help the patient constantly to enunciate clearly.

Callister describes his technic to prevent lateral creeping of the alar cartilage in harelip repair. Post and Mason consider the nursing care for infants who have had cleft lip repair. Gluecksohn and Dunn have described a new hereditary form of cleft lip in the house mouse.

Flanders presents a case of multiple facial fractures complicated by congenital cleft palate. The fractures were reduced and complete immobilization maintained by internal wire fixation as described by Adams. Adair reports a case of pharyngeal bursa associated with cleft palate. Boyne describes the results obtainable in surgery for cleft palate. Marino designed a combination sucker and periosteal elevator for use in cleft palate repair.

FACIAL INJURIES AND REPAIRS

Brown and Fryer emphasize the basic principles and care of severe compound facial injuries. Primary repair should be carried out as soon as the patient's general condition is satisfactory. It is preferable to do the repair in the first twenty-four hours before there are massive swelling, active infection and clot organization. General anesthesia is avoided when possible. The recognition of lost or displaced tissue and the evaluation of distorted functions form highly important components of the diagnosis. Roentgenograms of the facial bones must be obtained routinely, but they are not to be relied on completely. Facial wounds should be cleansed with soap and water. Cutting débridement should be completely avoided; many parts of the facial features may be thus preserved. Open packing of facial wounds is never indicated. Fractures of the nose, septum and palate frequently accompany severe injuries of the soft tissue. Facial fractures should be cared for within seven to ten days to avoid fixation of the smaller fragments which makes subsequent realinement impossible. Zygomatic displacement often occurs. Orbital damage in such cases may be severe. The globe may

be irreparably injured. The optic nerve may be severed and the ocular muscles torn. The lacrimal apparatus is frequently impinged on. In less severe cases binocular vision may be impaired. Bony fragments should be replaced in their normal position with the least possible manipulation. The antrum is often packed to maintain alinement of fractures of the orbital border. Fractures of the mandible may be cared for by interdental wiring, the Risdon arch, internal wire fixation or a combination of these methods. The restoration of a badly mutilated face may be accomplished by a complete analysis of the injury and a carefully planned procedure for repair. Pressure dressings on the face after injury and repair are as essential as for any other part of the body. Brown and Fryer also described the surgical repair of major defects of the face.

Pickrell, Kelley and Marzoni describe the surgical procedures followed in the treatment of a case of pseudoxanthoma elasticum. These consist of excision of the cutaneous lesion and primary closure of the defect. Cubero treats compound transverse fractures of the maxilla in the edentulous patient by inserting a tantalum wire through a small drill hole in the superior alveolus just above the former position of the second premolar. The wire is then passed over the zygomatic arch and brought back down through the gingival labial fold. A second wire is passed in a similar fashion on the opposite side. The two loops are then tightened, which brings the transverse fragment of the maxilla back into alinement. In patients with teeth the procedure is simpler; teeth are used for fixation, and drill holes are not needed.

McDowell describes a modification of the Denhardt mouth gag for adentulous mouths. Small pointed teeth are mounted on the jaws of the gag. These catch in patients' gums instead of slipping. This instrument does not interfere with the exposure necessary for major oral surgery.

Straith advocates the cooperation of the radiologist, the general surgeon and the plastic surgeon in the care of facial cancer. He believes that the plastic surgeon should limit his activities to the repair of the defect and that the responsibility of curing the carcinoma should rest with the other members of the team. Two cases are presented illustrating the repair of facial defects resulting from the eradication of carcinomatous lesions.

Campbell gives the detailed steps in the reconstruction of the left upper region of a jaw following the excision of the maxilla and the malar bones. Temporal muscle and iliac bone were used in the restoration. Curtis and Ecker present a case of cystic teratoma of the head. Travin summarizes the early maxillofacial surgery which he observed in World War II. A. M. Brown discusses facial restorations. Boos deals with facial rehabilitation. Himmel reviews the recent advances

in plastic surgery of the face. Rethi presents a method of operative repair of the retroauricular opening subsequent to radical mastoidectomy. Ellis, Widham and Latiolais discuss open reduction and fixation of fractures of facial bones. Crawford tells how to select appliances for typical facial fractures.

MANDIBLE

Byars considers in detail the preservation and restoration of mandibular function and contour. True bony ankylosis and fibrous obliteration of the temporomandibular joint may result from surgical procedures, trauma or infection. Adequate resection of the joint area alone will provide permanent relief. Such a resection may be approached through an incision in front of the ear reflecting the facial nerve and parotid gland. In the more difficult cases, however, it is best to enter the region through the neck, elevating all soft tissues from the ramus of the mandible upward to the condyle and coronoid process. For simpler cases the joint may be approached through the mouth. It is important that bony ankylosis be differentiated from trismus. A false ankylosis results from loss of soft tissues about the joint. Depressed zygomatic fractures may impinge on the coronoid process and thus limit the bite. The careful preservation of all soft tissues in this region at the time of an injury may prevent a future limitation of the mandible. Skin grafts to the mucosa and pedicle flaps to replace deeper tissue losses may be required in the treatment of false ankylosis.

Resection of a portion of the mandible produces many urgent problems. An adequate airway must be maintained. Swallowing must be provided for. Byars uses an internal bar fixation method which meets the immediate postoperative needs. At the same time it maintains the mandibular fragments in their original position and, thus, in the optimum position for future bony reconstruction. This method is particularly advantageous in the edentulous patient and in children. When the pathologic condition is such that a subperiosteal resection of the mandible may be carried out, the internal bar provides an excellent supporting framework for the regenerating bone. Mandibular contour is best restored and mandibular underdevelopment best corrected by the use of cartilage or bone transplants. Occasionally it is necessary to provide additional soft tissue in the form of pedicle flaps and oral skin grafts. Nasoplasty combined with the transplant procedures may further improve the general appearance.

Kanthak and Hamm describe the growth abnormalities of the mandible which produce facial deformities. Each is a result of a developmental anomaly of the growth center at the condylar head. Mandibular protrusion is of unknown etiology in most cases. It occurs in acromegaly, and certain families exhibit a genetic trend toward such a deformity. There are at least three surgical approaches to altering the

size and shape of the protruding jaw: (1) bicondylar resection, (2) resection of the body of the mandible and (3) osteotomy of the ascending rami. An operative correction in which the ramus is sectioned on both sides between the posterior border and the sigmoid notch is advocated. A bilateral fracture inferior to the neck of the condyle is thus produced. Mandibular retrusion in its most pronounced form is usually accompanied with ankylosis of the condyles. Treatment is difficult. In the less pronounced deformities the prominence of the chin may be brought out with an autogenous graft of bone or cartilage or with preserved cartilage. Unilateral hypertrophy of the mandible results from growth disturbances of one of the condyles. Most frequently a condyle is involved in a cyst, osteoma or chondroma. Excision of the enlarged and involved condyle usually results in the correction of the facial deformity. Orthodontic treatment is used after surgical intervention to obtain the best possible occlusion.

Padgett, Robinson and Stephenson analyze the etiologic, pathologic and therapeutic factors in their cases of ankylosis of the temporomandibular joint. Bony ankylosis is the most common cause of organic fixation of the jaw. Infection and trauma are the principal etiologic factors. Extra-articular fibrosis occurs one third as often as bony union. In cases of true ankylosis the best permanent results have been obtained by a wide resection of the condyle. Extra-articular fibrosis may in some instances be replaced by intraoral skin grafts or a cheek flap. The most obvious deformity in long-standing cases is on the normal side. There may be a marked recession of the chin and deviation of the mandible toward the affected side. All the teeth on the unaffected side are out of occlusion. On the affected side the preangular notch is deepened and atrophy of the masseter muscle is usually fairly definite. In true bony ankylosis there is no movement on the affected side, nor is there any pain on forceful opening. Roentgenologic examination may in some cases prove helpful.

Dingman reviews the surgical procedures which have been advocated for the correction of prognathic deformities of the mandible. Osteotomy is simple, and by its use possible injury to the inferior alveolar nerve is avoided. It does not mean the sacrifice of useful bone or teeth or the alteration of the mandibular arch. The operation is performed without oral contamination. Unfortunately, by this method the proximal segment cannot be controlled, and open bite may result. Mandibular section produces no disturbance of the muscles of mastication. There is no possibility of open bite resulting. Useful teeth, however, are sacrificed, and a section of bone is removed. A method of mandibular section is presented which is carried out in two stages and preserves the inferior alveolar nerve.

Straith and Lewis give the etiology, pathology, symptomatology, diagnosis and operative treatment of ankylosis of the temporomandibular joint. In the postoperative period emphasis is placed on the care of the false joint and teeth and the correction of secondary facial deformities. Ankylosis of the temporomandibular joint is essentially a surgical disease, and conservative treatment is useless.

Delk and Letterman find the combination of two technics, internal wire fixation with a Kirschner type pin and the use of an arch bar of the Risdon variety, effective in the management of the more complicated fractures of the symphysis.

Grimes and Stephens report the third histologically verified case of an adamantinoma metastasizing to the lung. Seven other cases of pulmonary metastasis have been reported but without pathologic verification. Freeman uses Sherman type plates of vitallium® bent in suitable curves to maintain function of the mandible after its resection. This provides a means of immediate postoperative fixation of fragments. The external facial contour is preserved. The airway is protected, and the feeding problem is simplified.

Kostrubala and Talbot report a case of myositis ossificans of the masseter muscle. There is a pronounced tendency for the recurrence of calcification after the bony mass is removed. Macomber, Shepard and Crofut outline the preoperative care and the necessary preparation subsequent to a bone graft. Osteoperiosteal tibial grafts, cortical bone osteotibial grafts and rib and iliac grafts are compared and the indications for each outlined. Postoperative care is considered, and the preparation of adequate sulci for dentures is discussed. Crowe considers the management of mandibular fractures and outlines the general care of the patient. Various types of fixation are enumerated. Continuous loop wiring with intermaxillary elastics, simple loop with intermaxillary wiring and arch bars with intermaxillary elastics or intermaxillary wiring were used most frequently. In the edentulous patient circumferential wiring of the mandible was done, the patient's denture being used as a splint. Liedman reviews the treatment of fractures of edentulous mandibles.

FACIAL PARALYSIS

Brown, McDowell and Fryer report additional findings and emphasize certain aspects of the treatment of facial paralysis with strips of fascia lata. It is important that the procedure be carried out at the earliest possible moment before much sagging has occurred. Excess skin may be excised, but this should be done before or after the fascia transplant operation. Fine wire is probably best for suturing fascial loops. The eye on the paralyzed side is made more comfortable by elevation of the facial tissue and by an external canthoplasty. A separate

loop of fascia passing through the lower lid and fastening to the temporal fascia and frontalis muscle may be useful. A frontalis fascial muscle flap opposite to the involved side may be used to tighten the lid sag. Production of Horner's syndrome is not relied on. The nasal labia fold, or at least a reasonable replica, should be restored. When the fascial strips are anchored to the temporal muscle, some facial movement is provided. It is of perhaps equal importance that the patient be taught to control the degree of expression on the normal side. Secondary adjustments may be necessary. Infection is the chief complication.

Owens reevaluates the surgical correction of facial paralysis by the insertion of fascial strips through the masseter muscle. The direct attachment of active muscular bundles to the paralyzed muscles gives a less satisfactory result than connecting fascial strips. With the fascia procedure, there is no risk of damaging the nerve to the masseter muscle. Furthermore, in time there is so much fibrosis that the muscle transplants act simply as straps. There is also danger of an early loss of muscle substance through infection. Muscle transplants, therefore, seem hardly worth while when the simpler procedure of fascia transplantation will answer the same purpose. The operative procedure is reviewed, and case reports are presented.

Greeley states that at times it is difficult to distinguish cases of facial paralysis which will show spontaneous regeneration and to anticipate the degree of regeneration possible. Paralysis resulting from the removal of extensive tumors in the parotid area or acoustic neuromas are considered permanent. Facial paralysis following trauma may result from edema. Some return of function occasionally is noted even a year after the original injury. However, in such cases the regeneration is usually only partial. A surgical repair should be done if there is no return of function after three months. Methods of repair are classified as neurosurgical, mechanical support with fascia lata, temporal and masseter muscle transplants and combinations of fascia and muscle transplants with mechanical supports. A severed facial nerve should be promptly sutured. If there is a loss of substance, a nerve graft may frequently be employed. Nerve substitution operations have not proved too satisfactory. Support of the paralyzed face with strips of autogenous fascia lata provides the simplest and most satisfactory method of plastic surgical correction. Muscular transplanting procedures may supplement this operation and provide some activation. In patients with long-standing paralysis, a face-lifting procedure on the involved side may further improve the cosmetic result by eliminating redundant skin. The use of tantalum in the form of wire or wire mesh is not recommended.

Adams employs multiple muscle transplantation to correct facial paralysis. The masseter muscle is used for reanimating the corner of the mouth and the lower portion of the face. The temporal muscle

restores support and function to the upper and lower eyelids. When the frontalis muscle of the opposite side is especially active, a portion of this muscle is transplanted into the upper paralyzed lid.

SCALP AND CRANIOPLASTY

Martin presents a series of 5 cases in which cancellous bone grafts were used successfully in the repair of small defects of the skull and supraorbital area. In the brow region two curved blocks of cancellous bone shaped to resemble the normal supraorbital ridge are preferred. Smaller chips are used to fill the deformity completely. Defects of the calvarium are best replaced by small bone chips as described by Mowlem. This method, however, did not prove as satisfactory as the blocks of cancellous bone for repairs in the brow region. Tantalum and acrylic materials are difficult to contour, and infection is a constant hazard in the supraorbital area. Bone is felt to be greatly superior to any foreign material.

Peer and Van Duyn report a case of congenital defect of the scalp and present an excellent summary of congenital skin defects. This particular case terminated fatally when the dried membrane overlying the brain was detached. Hemorrhage occurred from the superior longitudinal sinus. It is felt that scalp flaps should be used early in such cases before necrosis of the membrane occurs.

Alexander gives the histories and the operative procedures in 2 cases. A young woman with a burn of the scalp which resulted in an extensive loss of hair was satisfactorily treated by multiple excisions, transposition of flaps and skin grafting. In the second case there was a marginal ulcer of the knee following a childhood burn. This showed an epidermoid carcinoma. The entire lesion was excised and grafted.

Giannini, Weaver and Kloos give 2 case reports in which four defects of the head were repaired by tantalum plates and covered by regional flaps. These procedures were carried out in one stage.

SCARS AND KELOIDS

Block and Tsuzuki found a relatively high incidence of keloids and hypertrophic scars in Japanese persons sustaining burns from atomic bomb explosions. These survivors, however, healed under conditions conducive to the development of keloids. All second and third degree burns became rather severely infected. In some cases portions of the skin were destroyed that had not been primarily injured. These wounds were not grafted but healed over a period of many months. It seems impossible to evaluate the significance of direct action ionizing and neutron radiation in the production of these scars. Most of the patients were at sufficient distances from the center of the explosion to make

the amount of radiation received extremely low. Furthermore, the burns were limited to exposed areas of skin. No relation could be found between the distance from the ground center of the atomic explosion and the frequency of keloid formation. Studies prior to the war seemed to indicate a greater tendency for keloid formation among the Japanese people than among the white race. The tendency is not, however, as great as that observed in the Negroes. This study lacked sufficient follow-up and controls to arrive at any complete evaluation and understanding of keloid formation following injuries sustained from atomic bomb explosions.

Trusler and Bauer, in a discussion on keloids and hypertrophic scars, deal with the pathologic findings and etiologic factors. Technics to insure successful surgical treatment are outlined, and radiation therapy is advised. Continued application of pressure to a new scar is an important prophylactic measure.

Rubin recharted Langer's lines by placing a chemically impregnated felt pad against the skin of the face. A thin layer of the chemical was deposited, leaving the skin ridges exposed. A sensitized paper was then pressed lightly against the face and removed. Facial lines were thus charted. There is an individual variation of these lines. They run at right angles to facial muscles; muscular pull tends to separate the skin ridges. Nevertheless, incisions are best placed parallel to Langer's lines, but they must be carefully closed in layers and receive adequate postoperative care to obtain the best cosmetic scar.

Ulloa presents a dermocoaptor, a rod on which two hooks are mounted. One hook is placed at either end of a wound and adjusted so that the necessary tension is obtained to approximate the skin edges.

HEMANGIOMA

Figi emphasizes the marked deformity and dysfunction produced by hemangiomas. The strawberry capillary hemangioma is lined with radiosensitive embryonic endothelium. In infants these growths respond best to a screened radium plaque. Port-wine stains are composed of blood vessels whose endothelial linings are flattened and adult in type. There is little or no response to radiation. Nevertheless, patients have been treated with repeated applications of radium and continued roentgen therapy. Radiation dermatitis often results, and malignant degeneration may occur. The cosmetic result is poor. In women these lesions are perhaps best covered with cosmetics. In the male patient it may be necessary to excise the area and replace it with a skin graft. Cavernous hemangiomas in infants and children are preferably treated with interstitial radiation. Roentgen therapy and radium applications may sclerose these lesions, but they are also likely to produce telangiectasia

and scarring of the overlying skin. In adults, cavernous hemangiomas of scalp, face and oral cavity are best treated with electrocoagulation. Cavernous hemangiomas complicated by arteriovenous communications present a difficult therapeutic task. Unfortunately, even after such extensive vascular growths of the face have been completely removed or obliterated, the cosmetic result may be unsatisfactory.

Owens and Stephenson review 95 cases of hemangioma treated by the injection of sodium morrhuate and surgical excision. A historical account is given. The incidence, disposition, pathology and clinical diagnosis are discussed. Various forms of therapy in current use are outlined.

Crawford presents a series of 233 patients with 310 vascular tumors. One hundred and ninety hemangiomas were treated by the injection of sclerosing agents. Sixty-four per cent of the entire series of patients had good results. Sclerosing injections most nearly approach the natural processes which tend to produce spontaneous sclerosis in hemangiomas.

SKIN GRAFTING

Kernwein finds that recovery of sensation in split thickness skin grafts is patchy and never complete. The fine sensation exhibited by pedicle grafts is rarely obtained in the free split graft. A recipient area free of scar and covered by a good layer of subcutaneous tissue and intact nerve supply is the most favorable for growth and recovery of sensation.

Baxter, Entin and More observed dermatome donor sites as they healed at various temperatures. Between 82 and 50 F., the time necessary for complete epithelization of an area is inversely proportional to the height of temperature and directly proportional to the length of exposure. At temperatures of 65 to 53 F. complete epithelization is delayed three to four days. Pressure dressings hasten spontaneous epithelization of the donor area. The amount of exudate is reduced, and epithelial fibrosis is minimized.

Baxter and Entin found that split thickness skin grafts may be stored at temperatures between 8 and 0 C. for three weeks and still take when transplanted as autografts. More prolonged cooling at these temperatures diminishes graft survival to such an extent as to make the procedure not worth while. When skin grafts are exposed to temperatures of —20 to —78 C., ice crystal formation occurs. When transplanted, the skin is rapidly replaced with fibrous tissue even if it has been only briefly exposed. After longer exposure there is rapid disintegration of the graft. Refrigeration of homografts diminishes the time of survival of the transplanted skin grafts irrespective of the length of time the graft is exposed to cold or of the degree of coldness.

Gerrie directs attention to the fact that many plastic and reconstructive procedures are carried out in areas grossly contaminated with gram-negative pathogens. Grafting within the mouth and about the anus, covering extensive burns and decubitus ulcers, reconstructing the urethra and the external genitalia and grafting bone cavities are all done in heavily contaminated fields. Gram-negative pathogens apparently are contaminants and not infectors, provided body chemistry is normal, débridement adequate, graft fixation certain and pressure dressings well applied.

Barker was unable to sensitize the guinea pig to homologous skin protein. He points out that Loeb observed only lymphocytic infiltration following homotransplantation. This does not fit into the general concept of anaphylactic reactions which call for notable eosinophilia both locally and systemically. The reaction following autogenous skin grafting in man is in all probability not due to the sensitization to homologous skin proteins.

Jeremiah reports the development of squamous cell carcinoma on a donor area five months after a split thickness graft had been cut with a Padgett dermatome. Mills, Patterson and House outline their method of preparing granulating wounds for grafting. Most of such surfaces are the result of full thickness loss of skin from burns. By the use of wet sodium chloride pressure dressings applied over a single layer of fine mesh gauze, it has been possible to clean these wounds effectively.

Greeley describes reconstructive procedures for the repair of irradiation injuries. The causes, symptoms and pathologic changes, as well as the treatment, are discussed. It is of prime importance that all damaged tissue be excised and a good blood supply obtained before the application of a graft or flap.

Aufricht and Dowd have designed a mirror attachment for the Padgett dermatome. This makes it possible for the operator to visualize the actual area from which the graft is being obtained at that moment. Robinson reports two changes in construction of the Padgett dermatome. An aluminum drum has replaced the one of brass. There is a greater adherence of the rubber cement to the aluminum surface; practically no cement remains on the skin graft when it is removed. A different setting for the knife attachment has also been provided.

Steffanoff shows how a continuous skin graft 24 to 36 inches (60.9 to 91 cm.) long can be obtained by reapplication of the dermatome to an adjoining area. Swanker uses dermal fat grafts for the repair of incisional and inguinal hernias, muscular herniations of the extremities and initial fascial defects. Barker obtains grafts from irregular areas with the dermatome and the Ferris Smith knife after injecting saline solution subcutaneously.

Barker describes and illustrates the use of the "vacutome," which is a new instrument for obtaining split thickness skin grafts. The principle of suction is utilized. Kiskadden and McDowell describe their use of wet dressings.

Barker introduced a holder and "throw-away" blades for use in the Padgett dermatome. Marino also presents a thin disposable dermatome blade and mentions that a dermatome has been constructed in Argentina with a drum surface which is one fourth that of the standard Padgett dermatome.

Jenney considers a surgically sterile dry bed and tissue fluid as the two requisites for the growth of a skin graft. For this reason skin grafts are allowed to remain open immediately after grafting. The clot fixes the graft; no further pressure is felt to be essential.

COMPOSITE GRAFT

Brown and Cannon's introduction of the free composite graft as a practical method for repairing nasal defects is one of the most important wartime contributions to plastic surgery. Letterman and Brown summarized the use of this graft in the service volume of the "Cyclopedia of Medicine." The free composite graft is obtained from the ear; it consists of two surfaces of skin and intervening cartilage. The cartilage imparts stability and form to the graft; it makes such a graft possible by maintaining an internal stretch of the skin during that period when vascularity of the graft is being established. This free transplant makes it possible in a single operation to transfer a comparatively large bulk of tissue which is ideally suited for the repair and restoration of the nasal tip, columella and ala. Reconstruction of these structures with the composite graft was superior to all other methods. The grafts match the normal nasal border in color, contour and texture.

Armstrong utilizes the composite graft in the reconstruction after full thickness losses of the lower eyelid. The graft is easily obtained from the ear and provides a near morphologic restoration. The general contour corresponds to the lower lid, cartilage gives support, the color match is excellent and the grafts show no appreciable shrinkage. The skin on the orbital side is replaced with all available conjunctiva, which is best for the globe and at the same time gives an excellent blood supply to the graft. If sufficient conjunctiva is not available and a normal functioning eyeball is present, the skin is replaced with a mucous membrane graft from the lip. This method may be used in cases of traumatic losses and also in certain cases of ectropion.

The use of the composite graft will undoubtedly be extended to the restoration of other facial features with the successful free transplantation of larger amounts of composite tissue.

CARTILAGE

Kiehn, Friedell and MacIntyre studied the survival of bone grafts by means of radioactive phosphorus. Vital transplants of cartilage and iliac bone assimilate 40 and 60 per cent of the phosphorus as compared to the normal amount for living bone in the first twenty-four hours. There is a rapid increase in the percentage of assimilation during the ensuing days, and it approaches 100 per cent on the tenth day. Bone devitalized by boiling showed only a 7 per cent uptake of phosphorus as compared with normal bone. This was thought to be due to adsorption and considered negligible in comparison to the uptake by vital bone and controlled bone. Regenerated bone appears to be partially devitalized or dormant but may recover its vitality if left for a longer time in the animal. From these studies it seems highly probable that vital bone grafts form their own blood supply and integrate themselves as a vital part of a living substance from the time of their transplantation.

Brown and DeMere have given the details regarding the establishment of a preserved cartilage bank. The use of preserved homocartilage has several advantages. Procurement does not require a major surgical procedure on the patient. It is available in quantities; the quality and shape of the cartilage needed may be selected. It maintains the shape in which it is buried. Diced cartilage may be prepared from preserved material. It may serve as a temporary prosthesis prior to a later permanent implant of autogenous cartilage. Methods of procuring, cleaning and preparing cartilage for storage are given in detail. Aqueous merthiolate® solution (sodium ethylmercurithiosalicylate) forms a suitable preservative. It is stored in the ordinary electric refrigerator. Periodic bacteriologic studies are carried out.

DeKleine describes a chondrojet which facilitates the deposition of diced cartilage. MacMillan presents a point-eyed suture set. He has also described a multiple-bladed knife for dicing cartilage. Penn, Jankowitz and Bruwer pack diced cartilage into a glass cylinder lined with glycerin. A glass rod fitted into the cylinder acts as a piston for the deposition of the cartilage transplant.

CHRONIC ULCERS OF THE SKIN

Owens and Bethea advocate block excision of the chronic varicose ulcer with all the underlying and surrounding scar tissue. A suitable bed is thus prepared for the immediate application of a skin graft. Immediate grafting is preferable to a two stage procedure in which granulations are allowed to develop prior to grafting.

Dingman finds that chronic fissures of the lower lip frequently reoccur after simple excision because of the resulting linear scar. A

shortening from the vermilion border to the inner surface of the lower lip is also produced. These difficulties are alleviated by a combination excision of the chronic ulcer and Z-plasty procedure on the vermilion surface.

Teplitsky, Shapiro, and Robertson advise the radical excision of chronic ulcers of the leg. Defects are allowed to granulate in, and the surface is subsequently covered with a split skin graft.

Cooper and Hoen reemphasize the considerable quantities of protein lost in the transudate of the decubitus ulcer. High protein, high caloric diets, parenteral administration of protein, sulfanilamide and penicillin therapy and constant nursing care are of utmost importance. These, however, do not prevent the loss of protein from the local lesion. Fibrin foam effectively seals the wound and prevents oozing by its hemostatic action. Furthermore, it is felt that granulation and epithelization are enhanced. This technic is advocated as an effective method of preventing loss of protein and thus preparing the patient with decubitus ulcers for surgical closure by flap or skin grafts.

Royster advocates the surgical excision of cutaneous postdiphtheritic ulcers which fail to heal in sixty to seventy days. The resulting defect is then covered with a split thickness skin graft.

Steiss presents a case of bacterial aerobic gangrene which complicated chickenpox and resulted in an extensive thoracic defect. After primary grafting it was possible to excise and close the entire area.

Bors and Comarr use "buried epidermis" grafts in the treatment of decubitus ulcers. Such grafts provide temporary epithelization and thus restrict the loss of proteins prior to flap procedures. In certain cases such grafts have resulted in complete coverage of the defect. The procedure advocated is the "implantation" method of Wangensteen.

EARS

Conway, Newmann, Gelb, Leveridge and Joseph offer their solution for one of the most difficult problems in plastic surgery—reconstruction of the external ear. The contributions of Dieffenbach, Gillies, Pierce, Young, Aufricht, Brown and others are reviewed. Ten cases of reconstruction carried out in the past two years are presented. Satisfactory restorations may be obtained by using a carved costal cartilage framework. Fresh costal cartilage should be carved with a scalpel to minimize its tendency to curl. Two adjacent rib cartilages are resected en bloc. The convexity of the posterior aspect of the block is accentuated by splitting the rib cartilage longitudinally. By close attention to details a suitable framework is provided for the new external ear. All reconstructions were carried out by the elevation of buried free cartilage grafts from the head and the surfacing of the denuded area with a free

split thickness graft. A tubed pedicle was used at times to affect the appearance of the helix.

Peer presents a refined technic for reconstruction of the ear. In 1943 he described a method using diced cartilage grafts shaped in a vitallium® ear mold. The finer details of the cartilaginous framework was lost, however, because of the thickness of the overlying skin. The cartilage also tended to flatten out as it healed against the skull. These complications have been largely overcome by a trimming operation which constitutes an additional step in the previous process.

Steffanoff writes of a case of partial auricular restoration by the preparation and use of an auriculomastoid tube pedicle supplemented by a preserved cartilage implant and postauricular flap. Rosedale describes some deformities of the external ear and their correction.

EYELIDS AND ORBIT

Risdon describes several procedures which have been most helpful to him in surgery of the eyelid and socket. Full thickness skin grafts are used to reconstruct the lower and upper eyelids. Sockets are lined with split grafts; the remaining mucous membrane is not removed prior to this procedure. A permanent artificial eye is advisable only after the socket has been grafted for at least four to six weeks. Glass is still the material of choice for artificial eyes. Ptosis is corrected by the suspension of the upper eyelids by narrow fascial strips to the occipitofrontalis muscle.

Greear reviews the methods used in reconstruction of the orbit. He advocates lining the restored socket with buccal mucosa. Both cheeks and lips provide an adequate and readily accessible donor site. A skin graft to the orbit always maintains the characteristics of skin. A mucosal graft remains mucosa, but it is a much better substitute for conjunctiva.

Dupertuis discusses reconstruction of the eyelid in blinded war casualities. The use of lid tissue for restoration of the eyelid and the insertion of the free clavicular skin graft into the new lid is emphasized. In instances of serious loss involving bony structures, pedicle grafts are necessary. These should be outlined in such a way as to minimize the scar deformity of adjacent donor sites. Mucous membrane grafts obtained from the lips are the preferred lining even for the anophthalmic socket.

Burnham stresses the necessity of differentiating pseudoptosis on the basis of the true, acquired or congenital types. Ptosis repair corrects the cosmetic defect and prevents blindness from disuse, spastic torticollis and abnormal curvatures of the spine. Four varieties of corrective surgical procedures are available. The severed ends of the levator may be reunited in the traumatic form. Several methods utilize the frontalis

muscle by creating cicatricial bands between the brow and the lid. In a third type of procedure adhesions are created between the superior rectus muscle and the tarsus. Operations on the levator involve a shortening and advancement of this muscle.

Callahan comments on the causes of canthal deformities and reviews the anatomic features of the medial and lateral palpebral ligaments. To elevate and set back the displaced inner canthus, the medial orbital wall is exposed. Two small openings are made with a dental drill through the anterior or posterior lacrimal crest. A piece of stainless steel wire is then passed through the opening. The ends of the wire are threaded on small needles and brought through the canthal ligaments or tarsal plates. Twisting the wires gives the desired tension and provides permanent fixation. In event of loss of the medial orbital wall, attachment has been secured by passing wires through the nasal septum and anchoring them to the opposite nasal bone. A similar technic has been used for restoration of the lateral canthus.

Fox describes methods of repair and reconstruction of the lid. In the surgical correction of displaced canthi, Z-plasty procedures provide a source of tissue and alleviate lines of scar contracture. It is extremely important that the canthal repair be permanent.

Spaeth and Cappriotti report the use of isografts in the repair of bilateral ectropion of the four eyelids resulting from ichthyosis congenita. Friedenwald and Guyton pass abraided white silk suture in a rhomboid configuration connecting the dermis of the lid just above the lid margin to the fascial termination of the frontalis. This is a simple operation for the correction of ptosis.

Sherman, Clarke and LaRocca describe methods of lid and canthal repair. Callahan presents a case which illustrates his method of handling multiple deformities of the lids. A free skin graft, regional flap, intermarginal lid adhesions and canthus wiring are employed. Callahan describes a bipronged forceps for use in plastic surgery of the eyelid.

NOSE

Kazanjian presents two surgical procedures for the repair of nasal syphilitic deformities; both supply lining to the nose—one by means of a skin flap from the forehead and the other with flaps along the nasolabial line.

Martin feels that cancellous bone is superior to homologous or autogenous cartilage for the restoration of nasal contour. He describes the surgical procedure and presents several illustrative cases. Maliniac describes a compressive suspension splint for the management of comminuted nasal fractures. The instrument combines forward traction of the depressed fragments with narrowing of the dorsum. The maxillas provide distal fixation.

Fomon again presents his conception of the structural anatomy of the septum: ". . . the septum under static conditions does not furnish support to the nasal pyramid but acts only as a reserve safety factor."

In commenting on Fomon's thesis in which "the authors go on to prove by means of a mathematical formula that the septum is a superfluous structure which serves no purpose whatever, except possibly to provide patients for rhinologists" and in which they "advocate a dangerous procedure when they advise the complete removal of a septum," Safian states:

> As to the mathematical formula by means of which they feel that they have proved the septum to be an unnecessary structure, I am quite certain that in the near future someone will come forth with a more involved formula which will establish the fact that the entire external nose is a superfluous and redundant member.

Safian is "particularly concerned with the attempt of a group of men to create a synthetic literature. Their writings, which are finding their way into medical journals, are constantly growing more complicated in their verbiage, more faulty in their conclusions and more dangerous in their teachings."

Berson suggests that in cases of rhinophyma the growth first be completely excised and then the remaining skin over the dorsum of the nose mobilized and the tip raised so that the resulting defect may be closed primarily.

Davis and Berner review the etiology, physical findings, differential diagnosis and treatment of dermoid cysts of the nose. These tumors must be surgically excised. Instillation of iodized poppyseed oil should precede operation. Cases are reported in which the dermoid extended to the periosteum of the glabella and into the frontal sinus.

Rethi points out the right and wrong in rhinoplastic operations and presents a large number of patients who had been previously operated on and in whom subsequent revision was necesary.

Becker has devised a nasal speculum to obtain adequate exposure of the nasal dorsum during rhinoplasty. Rubin has improvised a rhinoplastic instrument for removing equal amounts of the alar cartilages.

Rubin, Robertson and Shapiro have used nasal, chin and forehead implants of polyethelene. This substance has also been used in the reconstruction of the ear. The substance is chemically inert and does not appear to have any unfavorable effect on body tissues. It is easy to work with and does not warp after implantation.

Ersner, Alexander and Gettes discussed the effect of rhinoplasty on the refractive error.

Seltzer, Pollock, Seeley, Fomon and others, Fomon and Syracuse, Ersner, Huffman and Lierle, Nabers, Becker and Daley described the rhinoplastic procedure.

Salinger has written on the role of the rhinologist in rhinoplasty.

UPPER EXTREMITY

Bunnell, Doherty and Curtis recognize a new entity in the hand consisting of a fibrous contracture of the intrinsic muscles. The pathologic findings are similar to those in Volkmann's ischemic contracture of the forearm. A typical deformity results. The thumb is straight but drawn into the palm near the second and third metacarpal bones. Cicatrix narrows the angle between the first two metacarpal bones. The fingers are drawn into flexion at the proximal joint and extension at the two distal joints. They tend to converge because of the exaggeration of the metacarpal arch. The hands become practically functionless if the impending condition is not recognized. The fascial covering of each intrinsic muscle may be split open prophylactically. Once the condition becomes established, the correction is more difficult. Some improvement in position and function can, however, be achieved. The detailed operative procedure required to open and maintain the angle between the first two metacarpal bones is given. The finger deformity necessitates operative procedures on the interosseous muscles which vary according to the state of these structures.

Cliffton directs attention to the unusual innervation of intrinsic hand muscles by the median and ulnar nerves. In an army center 5 cases showed persistent muscular function in spite of complete severance of the nerve which usually supplies the muscles tested. These exceptional cases are of importance in evaluating nerve injury preoperatively and postoperatively.

Barsky reviews methods of thumb restoration. In cases of partial loss involving only the terminal phalanx the scar on the distal end and palmar surface constitutes the principal problem. It lacks normal sensation. A free skin graft or distant flap, if used to replace the defect, likewise will never give evidence of stereognosis. It is best to shorten the thumb and use normal skin to replace the scar and cover the stump. Occasionally a functionless index finger may be transplanted to replace the thumb. In subtotal losses of the thumb a mobile metacarpus remains. Phalangization of the first metacarpal bone often improves prehensile strength. A functionless index finger may be substituted as in cases of partial loss. Blair and Byars used a toe to finger transplant in 1 such case. Total loss of the thumb includes a loss of the metacarpal bone. Hand efficiency is decreased almost 40 per cent. Prostheses prove satisfactory for some patients. Total surgical restoration of the thumb may be accomplished by several procedures. The index finger may be shifted and used after phalangization of its metacarpal bone. An abdominal tube flap with subsequent implantation of bone is a rather standardized procedure for constructing an immovable digit useful in apposition.

May gives the consequences of poorly planned immobilization of the hand which leads to contractures following trauma. Reconstructive procedures necessary to relieve the contracture are discussed. Lexer's technic for the operative correction of Dupuytren's contracture is presented.

Kitlowski and Banfield summarize their findings in epidermolysis bullosa hereditaria and present a case complicated by deformities of the hands and feet. Douglas presents an operation which aids in the formation of new nail beds.

Gill outlines the steps in reconstruction of a damaged hand. Adequate skin coverage is the chief prerequisite. Repair of nerves constitutes the second step in restoration. Atraumatic technic and the use of massive pressure dressings after injury will minimize residual stiffness of joints and simplify the problem of bony reconstruction. Iliac bone grafts, metacarpal shifts, amputated finger grafts and arthrodesis ot interphalangeal joints constitute the principal methods of bony reconstruction. Joint and tendon restoration make up the final step.

McCormack outlines the important considerations in the partially reconstructed severely injured hand. Any subsequent procedure must be based on a thorough study of the hand in its present condition and the original plan of reconstruction. There should be cognizance of the irreparable disability and the possible complications. Consideration of the future use to which the patient desires to put his hands is also important.

Tanzer and Littler state that a successful reconstruction of the thumb must provide forceful flexion and extension to permit grasping, opposability of the tip of the thumb to at least one digit and tactile sensation at the tip of the reconstructed thumb. A method for a subtotal or total restoration by transposition of an adjacent digit is outlined which meets these requirements.

Tanzer designs and rotates a pedicle flap from the side of an adjacent digit to correct an interdigital burn contracture. Bruner makes use of the extensor pollicis brevis tendon to restore abduction of the index finger. The surgical procedure is outlined.

Cano presents a case in which the digits of the right hand were reconstructed by using iliac bone grafts and skin pockets and tubed pedicle flaps. Blum advocates the use of myotomy to facilitate the repair of flexor tendons divided in the region of the proximal and medial phalanges of the fingers.

Liebolt briefly presents several important features of surgery of the hand. Methods of soft tissue, bone, nerve, tendon and joint repair are considered.

LOWER EXTREMITY

Converse outlines the repair of extremities with nontubulated pedicle flaps. Free skin grafts are unsuitable for covering densely scarred areas, bone and tendons. They are further contraindicated when sec-

ondary operations in the repaired regions are contemplated. Local transposed and rotation flaps are described and the limitations discussed. Types of distant flaps are enumerated. The true defect of an extremity is differentiated from the apparent defect, and instructions for mapping such a defect are given. When a flap is planned, the patient's comfort should be considered, a suitable donor area selected, the wound prepared for flap transfer and the design of the flap marked out. Transfer of the flap should be accomplished in as few operations as possible. Flaps from the opposite arm are preferred for covering defects of the fingers, interdigital spaces and the palm of the hand. Abdominal flaps are best for the dorsum of the hand, forearm and elbow. Thoracobrachial flaps are useful in the repair of arm defects. For the repair of defects of the lower extremities, cross leg flaps are more comfortable than the closed carried flap. The early covering of denuded bone and the replacement of unserviceable scar over bone are advocated. Flaps may be used in the treatment of osteomyelitis and traumatic osteitis; bone cavities may be covered. Pedicle skin flaps may also prove useful in lenghthening of the legs. The use of skin flaps in reconstructive surgery of the hand and nerve repair are briefly described.

Letterman finds that plexiglas® splints offer a distinct advantage in the immobilization of the lower extremities during the attachment of pedicle flaps. Such splints are made of monocurved sheets of plexiglas® and are so fitted and laced as to encase both lower extremities and maintain their relative positions during flap attachment. The splint is sturdy, clean, easily adjusted and quickly applied. Subsequent examinations and dressings of the flap and donor site are easily accomplished.

Stark has studied the arterial blood supply of the possible donor sites for pedicle flaps. Arteries are more prevalent on the medial aspect of the upper third of the leg and on the anterior aspect of the lower third of the thigh.

Lewin gives the indications for the use of free skin grafts and flaps in the repair of compound injuries of the lower extremities. The use of contiguous cross-leg and distant trunk flaps is described. The cross-leg flap is considered preferable to the distant tubed flap. Fewer operative procedures are involved, and less time is consumed in the repair.

Edwards evaluates the open jump flap method for the repair of defects of the lower extremities. Twenty-six open jump flaps and thirty-three abdominal tubed pedicles used to repair lower extremities are compared. One hundred and four days and six operations were required by the open jump method. Procedures using abdominal tubed pedicles averaged three hundred and thirty-three days and ten operations. Seven abdominal tubed pedicles were unsuccessful, while there was only a small partial loss in 1 case in which an open jump flap was used.

Macey treats lymphedema surgically. The entire disease-bearing tissue is excised and replaced by split skin grafts. Incapacitating recurrent cellulitis and lymphangitis are thus eliminated, and the extremity is returned to near normal size. Seven cases are reported in the series; in 5 excision of all the lymphedematous tissue below the knee was carried out. In another patient the procedure was confined to the medial aspect of the leg. The seventh patient underwent complete excision of the involved tissue below the elbow combined with skin grafting. A one stage procedure was done on the upper extremity, while treatment of the lower extremities was divided into two operations. Although the cosmetic result was not perfect, the functional result was excellent.

Requarth outlines flap repairs of surface defects of the lower extremities. Cross-leg pedicle flaps are felt to be superior to wrist-borne abdominal flaps. Cross-leg thigh flaps are preferable to those on the calf. Pedicle flaps should not be applied to unhealed wounds which would not support a free graft. Operative technic and methods of fixation are discussed.

Connelly reemphasizes the importance of removing all overlying scar tissue and its replacement by pedicle grafts in cases of compound fracture and nonunion. An adequate skin covering often provides the necessary impetus for complete healing of the bony fragments.

Wickstrom discusses the flap repair of defects of the lower extremities. Special reference is made to regional and cross-leg pedicle flaps. Soderberg uses massive combined tube and open flap pedicle transplants for the repair of deep surface defects of the extremities.

MAMMOPLASTY

Maliniac presents in some detail the attributes of transposition of the nipple and gland as opposed to a free transplant of the nipple in mammoplasty. Mammary function and the main blood supply of the breast should be preserved. The shape and dimensions must be harmonious and the scars unobjectionable. Free transplantation of the nipple violates a greater portion of these requirements.

> It is common knowledge that severance of the nipple and its terminal glandular endings from the excretory milk ducts is final; the continuity of the ducts cannot be restored. Physiologically this is tantamount to necrosis of both nipples.

It cannot be assumed that a hypertrophied breast is functionless. There are many cases in which mothers nursed their infants after mammoplasty with transposition of the nipple. Normal sensitivity and contractility are completely lost or greatly reduced when a free transplant of the nipple is carried out. Preservation of the blood supply is of course essential. Unfortunately, the blood supply to the breast has been inaccurately presented in many textbooks. The lateral thoracic artery

takes an equal part with the internal mammary artery in 55 per cent of the cases, and in 13 per cent it takes a predominant role in supplying the nipple and the glandular portion of the breast. A method of mammoplasty is presented in which transposition of the nipple and glandular tissue is carried out. The blood supply is preserved, scars are minimal and the breasts are symmetric and of good contour. In almost 80 per cent of the cases normal sensitivity of the nipple returns. The diminished sensitivity is in proportion to the amount of glandular tissue excised. Mammectomy is indicated for extremely large breasts with stasis of the nipple. In such cases an elevation of the skin can be created at the nipple site and the area tattooed.

Bames gives his one stage procedure for the reduction of massive hypertrophy of the breasts. The skin incisions used are those outlined for the typical buttonhole operation of Villandres-Dartique or Dufourmentel, with an added modification of a right angle inverted "V" incision extending from the new nipple locus to the circumference of the lower border. This modification provides for a more virginal conical contour. The breast mass is reduced by excisions of a radial sector of adequate size from the lateral inferior margin. This may be supplemented by a medial inferior sector in extremely large breasts. A combined splint and fixation suture maintains the shape of the breast in the early postoperative period.

Pickrell, Kelley and Marzoni record certain operative procedures used to extricate recurrent carcinomatous lesions from the thoracic wall after radical mastectomy. Immediate repair is carried out with superior, inferior, medial and lateral regional flaps, and in 1 case pericardium was successfully covered with a free skin graft after a resection of the thoracic wall.

GENITALIA

Counseller presents a comprehensive summary of the surgical treatment of congenital absence of the vagina and reports on a group of 79 patients treated prior to 1947. An additional 8 patients have been treated since that date. Congenital absence of the vagina is reported to occur once in 5,000 births, but Owens records only 6 cases in 500,000 patients admitted to Charity Hospital in New Orleans. Embryologically, the vagina develops in whole or part from the müllerian ducts, wolffian ducts and urogenital sinus. Rectal and ileal transplants, labial and thigh flaps, free skin grafts and simple pressure have all been used at various times in the reconstruction of the vagina. In the series reported 70 patients had vaginal constructions in which free skin grafts were used. Fifty-five obtained excellent results. In only 5 cases were the results considered to be poor or failures. They were due principally to infection, loss of grafts and resulting constriction and stenosis. In each case the grafts were applied and held in position by means of a

mold. It is important that such a form be worn for at least eight months. In 6 patients no graft was used and the vaginal space epithelized completely about a vaginal form.

Young and Benjamin advocate the repair of hypospadias in early childhood. The methods of repair are reviewed chronologically. They may be divided into two groups: construction of urethra by flap repair or by free graft repair. A satisfactory correction for chordee is described. A one stage operation for urethral construction using a free split graft obtained from the anteromedial surface of the arm is given step by step. This is a modification of a two stage procedure described by Nove-Josserand. The one stage procedure is thought to be a more satisfactory procedure than operations involving flap repair. The urethra has a normal exit in the glans penis, which permits a more normal type of urinary stream. The upper part of the arm provides a graft free of hair for urethra construction. Hair may grow after urethral construction by penile or scrotal flaps. No definite strictures have been observed. The poorest result with a free graft construction is a fistula at the anastomosis of the graft and the urethra. This is in contrast to the multiple fistulas which may arise in flap reconstruction. All the skin grafts have taken perfectly. The method is especially suitable for use in the reconstruction of hypospadias in children of preschool age.

Havens prefers the inlaying tubular skin graft method for restoration of the urethral canal in cases of hypospadias. Normal sexual functions, a urethral canal of good caliber and a meatal opening at the normal location in the glans penis are prerequisites for a satisfactory surgical correction. In a series of 29 cases there was only one failure. Best results are obtained with the inlying tubular graft if it is not inserted until the patient is about 16 years old. It is not felt that delay in repair until this age leads to any psychologic tendencies. There are some advantages to the correction of chordee in childhood.

Howard searched for remnants of the müllarian ducts in 14 cases of hypospadias. With penile hypospadias the utricle was normal. In cases of penoscrotal and perineal hypospadias the utricle was much enlarged and in some instances communicated with a well developed uterus. These findings are presented as evidence for an intersexual type of development as the basis for hypospadias rather than a purely local fusion developmental defect. Other causes of utricle enlargement are discussed.

Price and Penna studied the effectiveness of several drugs in preventing postoperative penile erections. One hundred and twenty-five patients undergoing circumcision were divided into five groups. One group received no medication. The second group received 5 mg. of diethylstilbestrol orally the afternoon prior to operation and then 5 mg. twice daily for five days. A third group was given 2 Gm. of sodium

bromide before operation and 1 Gm. three times a day postoperatively. Group four was given 1 mg. of estrogen hypodermically daily beginning on the day of operation. To a fifth group 5 mg. of stilbestrol was given twice a day for three to seven days preoperatively and continued until the fifth postoperative day. As compared to the control group I, 75 per cent of group II (diethylstilbestrol), 71 per cent of group III (sodium bromide), 84 per cent of group IV (estrone) and only 31 per cent of group V (stilbestrol) had erections. The preoperative and postoperative use of stilbestrol is therefore recommended for plastic procedures on the penis.

Davis and Berner review the reported cases of total avulsion of the skin from the penis and scrotum and give in detail the procedure they followed in the treatment of 2 additional cases. Split grafts were used to cover the shaft of the penis; the testicles and the spermatic cords were imbedded in the most adjacent regions of the upper area of the thighs. The optimum position for these structures is in the medial upper region of the thigh as far lateral as the spermatic cords allow. It is important in the application of the skin graft to the penis that full length scars be avoided.

Barclay and Hendrick present a case of spontaneous gangrene of the scrotum. Fournier described the three salient features of this condition in 1884. The onset is sudden in an apparently healthy male; the gangrene progresses rapidly. All the recognized causes of gangrene are absent. The testes and spermatic cords are rarely affected. Spontaneous repair usually occurs. The best treatment is radical removal of the necrotic tissue, which provides free drainage. Skin graft or flap repair is rarely necessary.

O'Conner and Kay report a case of phagedenic ulcer of the penis and its subsequent repair with scrotal flaps.

ANESTHESIA

Brown stresses the importance of following the golden rule in the selection and administration of an anesthetic for the patient undergoing plastic surgery. Many of the patients need repairs requiring several operations and anesthetics. It must be as pleasant an experience as possible, and the anesthetist must gain and retain the complete confidence of the patient. Local anesthesia is useful, but most patients prefer general anesthesia. Deep block of the fifth nerve is a valuable procedure. The technic is detailed. It is extremely important that the airway be carefully guarded. The surgeon and the anesthetist must form a team which can so cooperate and integrate their activities as to allow the anesthetist free access to the patient while the surgeon works undisturbed. The ward nurse and the house officer also contribute

significantly to successful anesthesia. During World War II, 40,000 operations were done on Colonel Brown's plastic surgery service at the Valley Forge Hospital, without a single fatality.

Pickrell and Cecil divide the reactions from local anesthetics into three types: (1) true hypersensitivity, (2) absorption of a toxic dose of the drug and (3) those resulting from the administration of the wrong solution. They are primarily concerned with the prevention of accidents which may be caused by the injection of alcohol, ether, hypertonic solutions of dextrose and boric acid. All these substances are common in the operating room. Certain biologically potent preparations, as well as such solutions as distilled water and hydrogen peroxide, also provoke severe reactions. These various solutions should be colored with distinct identifying dyes. Procaine hydrochloride gives a bright yellow color when it is added to an aqueous solution of paradimethylaminobenzaldehyde to which 2 cc. of concentrated sulfuric acid has been added. Filter papers immersed in this solution and dried will also give the same color reaction when procaine hydrochloride solution comes into contact with the paper.

Shaw reiterates the principles formulated by Apgar as essential for successful anesthetization of the patient undergoing plastic surgery. There must be no disturbance of the operative field, no increase in bleeding, maintenance of normal muscle tone, pleasant induction, smooth recovery and no encroachment on the operative field. On a basis of 630 elective operations the elements which determine the choice of anesthetics are discussed.

Lundy reviews the recent advances in anesthesia and calls particular attention to the use of the endotracheal tube in plastic surgery. The McGill technic is especially valuable for the patient who must be placed in the prone position.

MISCELLANEOUS TOPICS

Ivy gives a brief historical account of plastic surgery in the United States. The considerable part which the writer has played in the growth of this specialty makes the account especially interesting and graphic. Plastic surgery was recognized as a specialty after an outgrowth of the work of certain oral and general surgeons in World War I headed by Vilray P. Blair. The organization and function of the American Society of Plastic Surgeons, the American Society of Plastic and Reconstructive Surgery and, finally, in 1938 the American Board of Plastic Surgery exerted tremendous influence and helped to gain a place for the specialty in the field of American surgery. The activities and contributions of the American plastic surgeon in World War II are reviewed, and special reference is made to the plastic surgery service at Valley Forge under James B. Brown.

Longmire presents a case of traumatic loss of the trachea from the lower border of the larynx to the superior sternal notch. A lucite® tube connecting the upper and lower orifices provided a satisfactory substitute. The tracheal wall regenerated about the subcutaneously placed tube. After ten and a half months the tube was removed and reinserted. The unsupported channel did not provide an adequate airway during inspiration. After an additional six months another attempt was to be made to remove the tube permanently. This procedure is based on the experimental work of Daniel, who found in instances of circumferential defects of the dog's trachea that a wall of flattened epithelial cells regenerated about a glass tube bridging the defect. In certain of the dogs cartilaginous rings were subsequently formed in the surrounding connective tissue.

Ivy, Hawthorne and Ritter outline their method of constructing a skin-tube esophagus in the case of tracheoesophageal fistula.

Sanders presents his management of a case of stenosis of the oropharynx following tonsillectomy. An artificial oropharynx was constructed which was anchored to the upper teeth and which allowed for movement of the head and neck. This device provided a suitable base for the easy application of a split thickness skin graft after the scar tissue had been excised.

Brown, Byars, McDowell and Fryer have given in some detail the plastic surgery routine as outlined for the surgical house staffs at Barnes Hospital and St. Louis Children's Hospital. The preoperative care and postoperative procedures are outlined for the more frequent types of plastic surgical cases.

Seeley presents several forms which he has found useful to authorize operative procedures and the use of photographic material.

Pick summarizes ten years of plastic surgery in a penal institution. A physical deformity may prove a dominant cause of crime. The correction of defects of inmates influences their conduct in prison, and their reentry into society is made easier. Only 1.07 per cent of the 376 patients operated on have been returned to the institution in the ten year period. This is an unusually low percentage. An improvement in the appearance of established criminals tends to change the standards of their criminal practices on release. Congenital defects and facial disfigurement of the youthful law offender should be corrected. The delinquent boy may be thus saved the fate of the adult criminal.

SUMMARY

Brown summarizes the position of general plastic surgery in 1948. The specialty has received varied recognition among surgeons and medical organizations. To some it is a well defined specialty, while in another situation its work is distributed among several other services. A plastic

surgery service proves valuable in treating patients suffering from injuries and deformities of the face and jaw, and in cases which require skin grafts, flaps or scar adjustments in any other part of the body. Patients with burns may also be benefited greatly by the care of a plastic surgeon. The general plastic surgeon performs a great variety of different operations, and his training requires a broad general background. He brings into practice basic concepts and advancements in the biologic sciences. The recognition that "deep healing can be no better than the surface healing" has brought about close cooperation between the orthopedic, neurologic and plastic surgeons. Much knowledge gained from the general plastic surgery services of the army and navy can now be used to benefit civilian patients.

The individual patient is of first consideration to the plastic surgeon. In this field of surgery the physician-patient relationship is of extreme importance. This relationship can never emanate from central direction but must come from the individual surgeon.

Plastic surgery has grown up, it needs to grow further; to a large extent this can only come from wide understanding, but the challenge is to the individual surgeon who is called on to make substitution for deformed or lost normal physiology, and function, and anatomy.

2019 R Street, N. W.

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Surgical Clinics

DIAPHRAGMATIC HERNIA

VANDERBILT UNIVERSITY HOSPITAL
NASHVILLE, TENN.

DR. ROLLIN DANIEL: The subject of the clinic today is diaphragmatic hernia.

The development of the diaphragm is complicated, and as a result of irregularities in its development, herniation of abdominal organs may occasionally occur into the thoracic cavities. The diaphragm is a strong muscle in the normal person. It has a central tendon into which muscle fibers which radiate toward this tendon insert. It is perforated normally by three foramens, through which the aorta, the esophagus and the vena cava extend.

The aorta is retroperitoneal, and there is never, so far as I know, protrusion of viscera through that opening. The vena cava is surrounded by strong muscles and tendons, and if herniation occurs through that foramen, it certainly does so extremely rarely.

The esophagus, on the other hand, is surrounded by circular muscle and connective tissue which varies in thickness and in strength, and the esophageal foramen varies to some extent in size in different persons so that intrathoracic protrusion, at least of the stomach, through this foramen does sometimes take place; this constitutes one of the types of diaphragmatic hernia which are sometimes seen.

The muscle which makes up the diaphragm and which inserts into the central tendon arises anteriorly from the posterior surface of the xiphoid process and the posterior sheath of the rectus abdomini muscle; other digitations arise from the costal cartilages of the fifth and sixth ribs and from the cartilaginous and osseous portions of the seventh and eighth ribs and from the last three ribs laterally and posteriorly.

Fibers of tendon and muscle extend posteriorly from the xiphoid process and on each side from the costal cartilages obliquely toward the central tendon. Triangular defects may be present on either side of the substernal tendon, through which abdominal viscera, particularly the stomach or colon, may protrude into either pleural cavity. These openings have been called the foramens of Morgagni or Larrey's spaces. The term subcostosternal hernia is used by Harrington.

The hernias which take place through these openings almost always have a hernia sac which protrudes into one or the other pleural cavity. Herniation takes place more frequently on the right side, into the right pleural cavity, than on the left side.

In the development of the diaphragm, there is a fusion of various structures which develop in a rather complicated fashion. In fetal life there may be either a failure of complete development or complete absence of some of these structures, and when this occurs there may be evisceration from the abdominal cavity into a pleural cavity. Such defects occur in the posterior portion of the diaphragm,

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The surgical clinic on diaphragmatic hernia convened at Vanderbilt University Hospital, Nashville, Tenn., on Wednesday afternoon at 4 o'clock, June 15, 1949, with Dr. Rollin A. Daniel Jr. presiding.

more frequently on the left than on the right side. The opening is known as the pleuroperitoneal foramen or pleuroperitoneal canal. It is called sometimes the foramen of Bochdalek.

When herniation occurs through this opening, there is almost never a hernial sac. Occasionally, apparently, there may be a sac composed of pleura or peritoneum or both. The opening varies in size a great deal.

We prefer to classify the diaphragmatic hernias in as simple a manner as possible. For purposes of simplicity we have chosen to classify them in two categories based on etiology, the first being the congenital diaphragmatic hernias.

The congenital hernias can be divided into various types in many different ways. We may divide them, for instance, into those which have a hernia sac and those in which there is no sac. As I have said, the latter type, that in which there is no sac, is almost always the hernia of the pleuroperitoneal foramen.

The hernias which occur through the esophageal hiatus always have a sac. Herniation takes place into the mediastinum. The hernia of the foramen of Morgagni or the subcostosternal foramen also has a sac. Herniation takes place into the pleural cavity. Herniation through the pleuroperitoneal foramen occurs before birth. In other words, the infant may be born with some or almost all the abdominal viscera in the left pleural cavity. If this foramen persists on the right side, it may be covered by the liver so that there is a herniation only of a portion of the liver into the right thoracic cavity and no symptoms are produced. On the other hand, herniation of the intestine may occur on the right, posterior to the liver, and upward through this opening in the right side of the diaphragm into the pleural cavity.

In cases in which a complete opening does not exist at the time of birth, herniation may take place later in life, probably as a result of the stretching of a poorly developed membrane which is present at the time of birth. In other words, the diaphragm is intact at the time of birth but as time goes on, with the upward pull caused by the negative pressure in the thoracic cavity and the upward pushing of the abdominal contents from below, this poorly developed membrane, composed of pleura or peritoneum or both, gradually stretches and becomes larger in size.

Thus, symptoms may not be present at the time of birth and indeed may not be present until a person has reached adult life. The esophageal hiatus hernia is more apt to make itself known in middle age or in the older age groups. With the anterior hernia, of the substernal space, symptoms may be produced at any time after birth depending on the size of the sac and the viscera which are contained within it.

All the aforementioned hernias may be classified, then, as congenital forms of hernia, even though there is no herniation at the time of birth and the hernia is acquired later.

The other large group is composed of those which are produced by trauma, either by a penetrating wound of the chest caused by stabbing or gunshot or by rupture of the diaphragm as a result of blunt trauma or a crushing force. Very rarely, perhaps, herniation takes place as a result of rupture caused by infection, the subphrenic abscess being an example. This occurs more frequently on the right side than on the left. If rupture takes place through the right side of the diaphragm, the liver usually fills the hole. Furthermore, there is a marked inflammatory reaction about this abscess whether it occurs above or below the diaphragm, and adhesions are formed to the extent that herniation of viscera through the diaphragm is not likely to occur.

I think that one might ponder the question of whether or not lifting and such forces which are exerted by coughing and straining might produce diaphragmatic hernia in a person who has some developmental abnormality of the diaphragm.

Dr. Billings, would you care to comment on that possibility?

DR. F. T. BILLINGS: It would seeem unlikely that a diaphragmatic hernia would occur in a person whose diaphragm was normal at birth. We have, of course, no way of knowing whether this is true or not, since at the time of operation the foramen through which the herniation has taken place is already stretched.

DR. DANIEL: Dr. Clark, will you comment on the development of the diaphragm in the embryo?

DR. SAM CLARK: The development of the diaphragm, as Dr. Daniel has pointed out, comes from more than one source. The septum transversum, which develops high in the cervical region, at first migrates, picking up muscle at the level of the third and fourth cervical segments and the innervation there of the phrenic nerve; then, as it progresses in this relative migration caudalward, the pleuroperitoneal folds appear dorsolaterally. A portion of the diaphragm develops from each body wall laterally and a portion from the dorsal mesentery.

The diaphragm is covered by the lining of the celomic cavity.

These separate components arrive at the lower level, at the upper end of the mesonephros, and then fuse normally at about the eighth week of life, when the embryo measures around 20 mm. in length. A defect, then, present at birth usually would have persisted from that early age.

One reason that herniation is commoner on the left than on the right might be that the liver, as it develops before birth from the gut, tends to go toward the right and form a large mass which acts as a kind of plug, leaving more exposed the left surface of the diaphragm.

As the stomach develops it has a ventral and a dorsal mesentery fused with the caudal face of the diaphragm, and as it rotates it too goes to the right, which helps to expose more the left side of the diaphragm.

DR. BILLINGS: At what stage do the colon and the small intestine develop in relation to the normal closure of the diaphragm — after or before?

DR. CLARK: These structures have already appeared in the gut caudad to the diaphragm but elongate greatly after the diaphragm is closed. The gut as it elongates enters the umbilical cord as a ventral hernia, and then, as the body wall develops, it is drawn back. Most of the lengthening of the gut and the rotation of the large intestine and lengthening of the small intestine occur after the time at which the diaphragm closes.

DR. DANIEL: Is it not true, Dr. Clark, that the pleuroperitoneal membrane is the posterolateral portion of the diaphragm in the adult?

DR. CLARK: Yes.

DR. DANIEL: The membrane develops first as layers of pleura and peritoneum opposed to each other, and the muscle later grows in from the side?

DR. CLARK: That is correct.

DR. DANIEL: Before the case histories of several patients with diaphragmatic hernias are presented, Dr. Billings, would you comment on the frequency of occurrence of the several types?

DR. BILLINGS: Although the most dramatic type of herniation through the diaphragm, of course, is that which occurs in infants shortly after birth, these are by no means the commonest. Moreover, subcostosternal hernias are also unusual.

The herniation which is most commonly encountered is the paraesophageal hernia. Figures on the incidence of this type of herniation vary tremendously in different clinics, based, I imagine, chiefly on the perspicacity of the clinician and the roentgenologist. The incidence varies between 60 and 80 per cent of all diaphragmatic hernias which are seen. At the Mayo Clinic it is stated that from 1 to 4 per cent of all patients with pain in the upper abdominal area probably have asymptomatic paraesophageal hernia. The incidence, in our experience, would not be as high as this.

DR. DANIEL: The esophageal hiatus hernia is certainly the most frequent type of diaphragmatic hernia which results from maldevelpoment. The hernia of the pleuroperitoneal canal comes second and the subcostosternal hernia last in frequency. It is difficult to place the incidence of the traumatic hernia here, because it varies in frequency so much, depending on whether the period is one of war or peace. It is seen not too infrequently in civilian life as a result of automobile accidents and particularly of stab wounds.

Dr. Francis, will you comment on the frequency of the paraesophageal hiatus hernia as compared to the frequency of the congenitally short esophagus?

DR. HERBERT FRANCIS: There is quite a variation in the length of the esophagus in various persons. The esophagus may end 2 or 3 inches (5 to 7.6 cm.) above the diaphragm. In that type there is always a varying amount of stomach in the intrathoracic area. It may be the upper part or the cardiac end, or, in some instances, all the stomach may be in the thorax. The last is relatively uncommon. Most commonly there is a large pouch of the stomach in the chest.

There are other types of less degrees of shortening in which there may be little or no intraabdominal esophagus. Normally 3 or 4 cm. of the esophagus is below the diaphragm. At times congenital shortening is such that there is no intra-abdominal esophagus. It may be difficult to differentiate this condition from paraesophageal hernia, and the two conditions may at times occur together.

The surgeons usually report a higher incidence of congenitally short esophagus than do the radiologists. I find it difficult to show the minor degrees of shortening of the esophagus and to separate them distinctly from the paraesophageal hiatal hernia.

I would definitely say that the paraesophageal hernia, in my experience, has been considerably commoner, probably four or five times as frequent, as the congenitally short esophagus of all degrees. This is contrary to most surgical reports.

DR. DANIEL: There is another type of shortening of the esophagus which has been cited by some authors, the frequency of which I am sure I cannot establish; this may be acquired as a result of peptic ulceration of the lower end of the esophagus with contracture of scar tissue as healing of the ulcer occurs and a consequent shortening of the lower end of the esophagus, the cardiac end of the stomach being drawn upward to some extent through the esophageal hiatus.

DR. BILLINGS: I should like to ask Dr. Francis whether he could make a statement on how often a paraesophageal hernia might be discovered in an examination of a statistically significant number of patients over 50 years old.

DR. FRANCIS: I have no actual statistics on that. I would say that if you take the older age group possibly as many as 5 per cent might show hiatal hernias of varying sizes. There is also a variation in the sex incidence. It is definitely commoner in females.

DR. DANIEL: Do you have any explanation for this difference in sex incidence of hiatal hernia, Dr. Francis?

DR. FRANCIS: No, I do not.

DR. BARTON MCSWAIN: That ought to be explainable on the basis of the increased intra-abdominal pressure which is caused by pregnancy.

DR. FRANCIS: It certainly is true that hiatal hernia is not uncommon with pregnancy, particularly in the later months. It is very significantly noted that more persons have hiatal hernia in the latter months of pregnancy than during the early months. After delivery there may not be any hernia demonstrable by roentgen examination.

DR. HENRY BLANDSFIELD: Does postoperative diaphragmatic hernia occur often after a transthoracic approach in the upper region of the abdomen?

DR. DANIEL: It has happened only once in our experience.

DR. J. C. PETERSON: If pregnancy is an etiologic factor, why is it that the great majority of hernias do not appear until after the age of 50?

DR. DANIEL: I think it is important to remember that we examine the stomachs of persons who are middle aged or past middle age more frequently than those of persons in the younger age groups. I think it might be rather difficult to establish the frequency of hiatal hernia in children, for example. We do not know whether they exist occasionally in children or not because we do not do gastrointestinal examinations with a barium meal nearly as frequently in children as in adults. Is that not correct, Dr. Peterson?

DR. PETERSON: Yes. For this reason, they are only occasionally discovered.

PATIENT 1

DR. WALTER DIVELEY: The first patient is a 5 day old, white male infant, who was perfectly well until five hours before his admission to the hospital. He became fretful and was noted to be doubling up with abdominal pain. He was short of breath and cyanotic.

On admission, he was acutely ill, dyspneic and cyanotic. The heart was shifted toward the right, and there were dulness and absence of breath sounds in the left side of the chest. An operation was performed through a high left rectus incision, and it was found that practically all the small bowel and the ascending colon, cecum and transverse colon were present in the left thoracic cavity, having protruded through an opening in the posterior portion of the diaphragm, about 7 cm. in length. The contents were reduced into the abdominal cavity with ease, and the diaphragmatic defect was easily repaired. There was considerable difficulty in closing the abdomen after all the viscera had been replaced in the abdominal cavity. The abdominal wound could be closed only with tension, and through and through sutures were used.

The only complicating factor was the development of a ventral hernia.

DR. DANIEL: There are several points which I think are interesting in connection with this type of hernia. It represents what is called congenital absence of the left side of the diaphragm. This does not mean the absence of the whole diaphragm but of the posterior portion, which would have been formed by the proper development of the pleuroperitoneal membrane.

The child was born with most of the viscera in the left pleural cavity. The abdominal cavity literally was not large enough to contain the viscera. This is an important thing to keep in mind in the repair of the type of diaphragmatic

hernia under discussion. I think the repairs should all be done through the abdomen in infants because the greatest problem is frequently the closure of the abdominal wall after reduction of the hernia.

The hernia is reduced by placing a catheter up through the hernial ring. One can slip a finger under the leaf of the diaphragm and then slip a catheter up to the apex of the pleural cavity. If this is not done, a vacuum is created when the intestine is pulled out of the left pleural cavity, which makes reduction almost impossible. The viscera are brought out of the abdominal incision, and then the left side of the diaphragm can be easily exposed and closure can be accomplished. One is then faced with the problem of replacing the viscera and closing the abdominal wound.

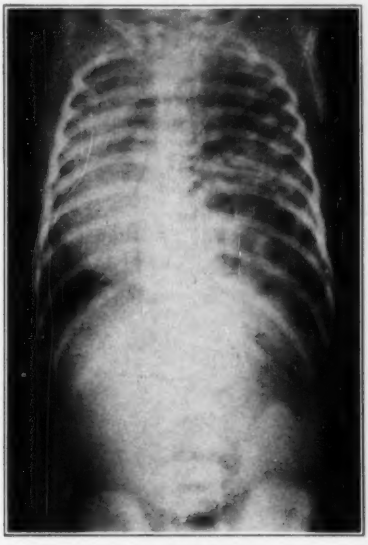

Fig. 1 (case 1).—Hernia of left pleuroperitoneal foramen (foramen of Bochdalek). Preoperative roentgenogram of infant 5 days old. The left side of the chest is filled with dilated bowel and the heart is displaced markedly toward the right.

In the case reported, the abdominal wound was closed under great tension with through and through sutures. I am sure closure of only the skin and subcutaneous tissues at the time of the primary operative procedure, as suggested by Ladd and Gross, is a better method, a postoperative ventral hernia being purposely left. The abdominal wall will then stretch, so that in about ten days or two weeks one can reopen the wound and effect a proper closure secondarily.

Children with these hernias should be operated on early. The left lung is always collapsed. At the time of birth, as soon as feedings are started, the intestine becomes dilated with fluid and with gas and occupies a great deal more space than it did before birth. The mediastinum is therefore pushed over toward the other side. The right lung is impinged on, and the child may die as a result of pulmonary insufficiency.

The dangers of intestinal obstruction are probably not great unless the opening in the diaphragm is small.

DR. BLANDSFIELD: There was no sac in this case?

DR. DANIEL: No. The edge of the opening was smooth and covered with mesothelium, and this covered edge was excised before the diaphragm was repaired. The diaphragm is brought back against the posterior wall and sutured to the ridge there, if one is present. If not, it is sutured to the chest wall, the intercostal muscles and the periosteum of the ribs.

DR. PETERSON: The early recognition of this in infants is of great importance so that the operation can be carried out at the optimal time, before the intestine has been distended. The lesion should be suspected in any infant who vomits and has cyanosis, particularly when the normally distended abdomen is scaphoid. Unfortunately, this relatively rare occurrence must be thought of before the

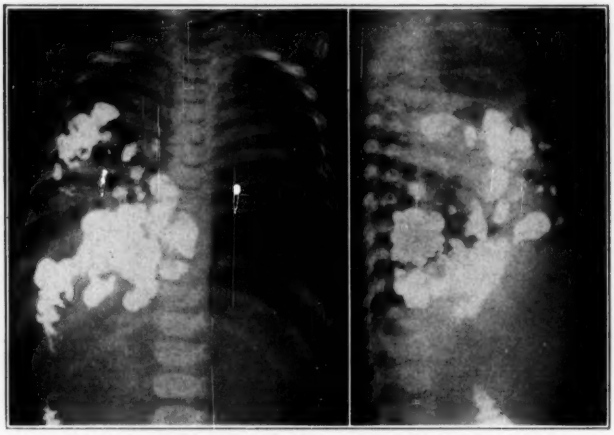

Fig. 2 (case 2).—Hernia of pleuroperitoneal foramen on the right side. Preoperative roentgenogram following barium meal.

diagnosis can be made. Even the shifting of the mediastinum may not be appreciated in a small infant in whom it is difficult to percuss the chest with accuracy. The expected dulness over the affected side may be replaced by tympany if the viscera are filled with air.

PATIENT 2

DR. DIVELEY: This is a 7 month old boy in whom, at the age of 9 weeks, projectile vomiting developed after each feeding. A private physician had noticed visible peristalsis in the upper region of the abdomen moving from left to right and an olive-sized mass in the right upper quadrant, and a diagnosis of congenital hypertrophic pyloric stenosis was made. Roentgen examination, carried out in another hospital, was thought to confirm this diagnosis.

He was treated with frequent feedings and with sedation and improved considerably. Seven days prior to his admission, an infection of the upper respiratory tract developed, and he vomited repeatedly. Examination revealed what

were considered to be signs of pneumonia in the right lower lobe, and a roentgenogram of the chest showed what appeared to be loops of bowel at the right base.

The patient was operated on through a right posterolateral thoracic incision. Practically all the small bowel and a good portion of the transverse colon were present in the right pleural cavity, having entered through a 2 by 4 cm. space in the posterolateral aspect of the diaphragm. The intestine could not be replaced into the abdominal cavity. A short right upper rectus incision was made, and as the loops were replaced into the abdominal cavity, the patient was eviscerated. The phrenic nerve was crushed, and the repair of the diaphragm and abdomen was then easily performed.

DR. DANIEL: This is a hernia of the pleuroperitoneal foramen on the right side. The intestine extended into the right pleural cavity posterior to the liver. The thoracic incision was made because it was believed that repair of the diaphragm could be accomplished much better by exposing the diaphragm transpleurally. We felt that exposure of the diaphragm from below might be extremely difficult.

We left the abdominal wall prepared and exposed at the time of operation because we felt that we might have to make an abdominal incision in order to reduce the hernia, and this proved to be necessary. After closure of the diaphragm, the abdominal wound was closed easily. There was little tension.

I believe that the use of the two incisions is a proper operative approach in this type of lesion. I do not feel that the making of two incisions is harmful, and I think that accurate and proper closure of the diaphragm can be accomplished better through a thoracic incision.

DR. FRANCIS: In this case cystic disease of the lung might have been suspected in that the child was thought to have had pneumonia and gas shadows were visible on the plain roentgenogram. The barium meal will, of course, clarify any confusion which may exist.

PATIENT 3

DR. DIVELEY: This is a 30 year old coal miner who entered with a history of epigastric fulness and discomfort of three or four years' duration following meals. He had noted gurgling sounds in the left lower region of the chest. His discomfort had always been more marked when he was lying down. There had been no nausea or vomiting. The diagnosis of diaphragmatic hernia was suspected and was confirmed by roentgenograms. Operation was performed through the left side of the chest. Practically all the small intestine, all the stomach, part of the transverse colon, a portion of the greater omentum and the spleen were in the left side of the chest. There was a defect in the posterior aspect of the diaphragm which measured 4 by 10 cm. The hernia was easily reduced. The defect was repaired with some difficulty, in that the lateral portion of the diaphragm was closed with considerable tension. For that reason a fascia lata graft was taken and sutured over the line of closure to reenforce it further. The phrenic nerve was crushed. His postoperative course was uneventful.

DR. DANIEL: It was difficult to be sure that this was a congenital hernia, though I believe it was. One might speculate on the possibility which Dr. Billings has mentioned, that is, that there was originally a membrane present which was weak as the result of failure of proper development and that at some time it ruptured so that the patient had in truth a traumatic diaphragmatic hernia. There is no history of direct trauma, however, and I think such a possibility is unlikely. I believe that this was a congenital hernia which had been present throughout life.

PATIENT 4

DR. DIVELEY: This patient is a 39 year old coal miner who gave a history of epigastric fulness after meals followed frequently by vomiting, with relief of discomfort, of fifteen months' duration. He had often vomited undigested food

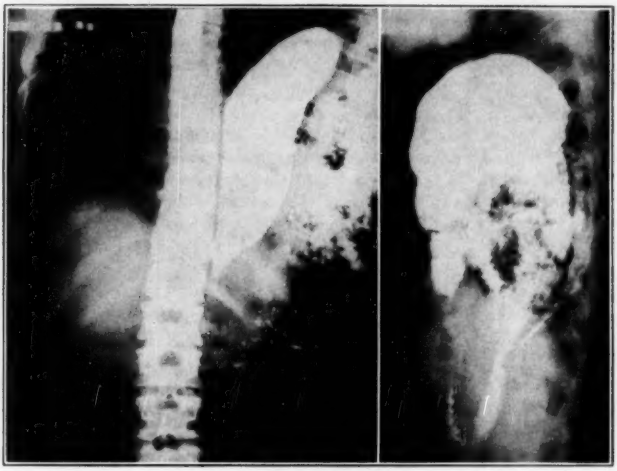

Fig. 3 (case 3).—Congenital hernia of the pleuroperitoneal foramen in a man 30 years of age.

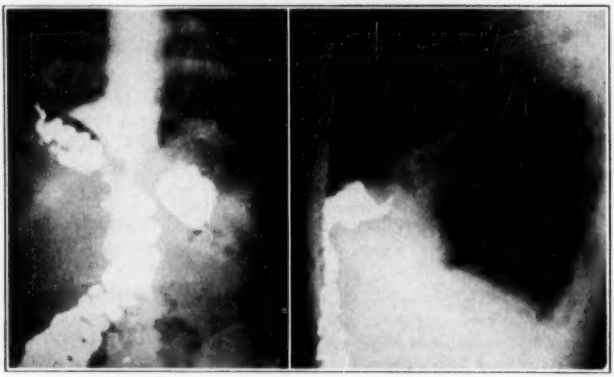

Fig. 4 (case 4).—Hernia of the substernocostal foramen (foramen of Morgagni) in a 36 year old man.

which had been eaten two or three days previously. There had been no hematemesis or true abdominal pain. He had lost 40 pounds (18 Kg.) in weight. He was seen by his private physician, who ordered a series of gastrointestinal roent-

genograms. This revealed herniation of the colon into the right pleural cavity through a defect in the right substernal region. The stomach was greatly dilated and emptied very slowly.

The patient was operated on through a right upper rectus incision, and it was found that the entire transverse colon and omentum were in the right thoracic cavity. The colon was easily brought down into the abdominal cavity. The stomach was considerably dilated and had been rotated 180 degrees, so that pyloric obstruction had been produced. There was a large hernia sac which extended up into the right thoracic cavity, and this could not be freed transabdominally. The right thoracic cavity was opened through the sixth anterior intercostal space, and a large sac was found which was adherent to the pericardium and to the mediastinal pleura over a wide area. This was freed and excised at its neck, the phrenic nerve was crushed and the defect of the diaphragm, which measured about 4 by 10 cm. was repaired. The postoperative course was uneventful.

DR. DANIEL: He has gained about 30 pounds (13.6 Kg.) weight since the operation. This is an example of hernia in the subcostosternal space. The hernia may not have existed at the time of birth. It may have resulted from a gradual stretching of the membrane in that region upward into the right pleural cavity.

The symptoms were produced by pyloric obstruction, but the stomach was not in the thorax; partial pyloric obstruction was produced by herniation of the colon and omentum into the right pleural cavity, which produced traction on the antrum of the stomach and a rotation of the antrum to at least 180 degrees. This was easily demonstrated at the time of operation. By simply replacing the colon in the abdominal cavity the pyloric obstruction was completely relieved.

DR. BILLINGS: It is interesting to note that there was no symptom of a lesion of the colon. The patient had an exceedingly large stomach, from which something like 8,000 cc. of contents was removed prior to operation.

DR. DANIEL: I should like to point out again that two incisions were made here and that the chest wall was prepared and left exposed before operation because we felt that it might be necessary to repair the hernia from above.

DR. MCSWAIN: What were your reasons for not making a transthoracic incision in the first place?

DR. DANIEL: The reason we made an abdominal incision was because we felt that we could explore the abdomen better through an abdominal incision. You may remember, Dr. McSwain, that he had partial pyloric obstruction. We believed that it was important to examine the duodenum and the stomach adequately and that we might be able to repair the hernia through the abdominal incision.

DR. MCSWAIN: Ordinarily, with one in the right pleural cavity, you would use a transthoracic approach as you did on the child?

DR. DANIEL: Yes.

DR. FRANCIS: The patient had three roentgen examinations prior to his admission to this hospital. None of these was complete, and the diagnosis therefore was not made. When the gastrointestinal series was done, he did have pyloric obstruction, and we were unable to say what it was due to until the barium had reached the colon.

PATIENT 8

DR. DIVELEY: This is a 3 month old female infant who had not gained weight adequately from birth. For four days prior to her admission she had vomited repeatedly. On examination, she was seen to be a poorly nourished

and poorly developed infant. Physical examination of the chest revealed dulness and suppression of breath sounds over the right lower region anteriorly.

The barium meal showed the distal end of the stomach to be in the right thoracic cavity. The patient was operated on through the right side of the chest, and a large hernia sac was found which extended almost to the apex of the right pleural cavity. This was opened and was found to contain a large portion of the stomach which was dilated. The sac was excised and the phrenic nerve crushed, and the defect, which was paraesophageal in location, was easily closed.

DR. DANIEL: Dr. Francis, would you like to comment on the roentgenologic examination of the child?

DR. FRANCIS: This is an instance of paraesophageal hernia in an infant which is relatively uncommon in our experience but probably does happen more frequently than we have the opportunity to find out by roentgen examination.

DR. DANIEL: It is interesting not only that this was a paraesophageal hernia

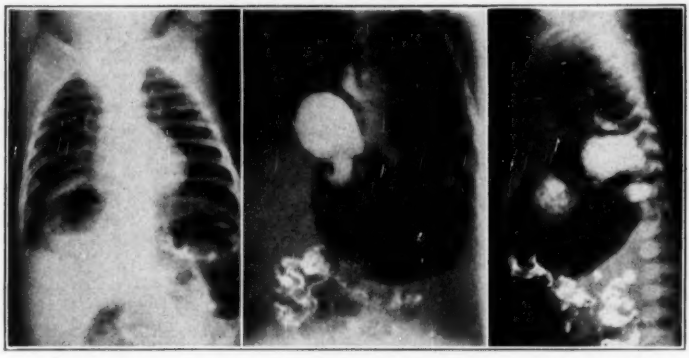

Fig. 5 (case 5).—Preoperative roentgenogram of a paraesophageal hiatus hernia on the right side, in a 3 month old girl. This type of lesion is very rare.

with a large sac in an infant but that symptoms again were produced by obstruction of the pylorus.

DR. PETERSON: While these lesions may occur with a frequency that is unsuspected, they do not give rise to symptoms with any great frequency in childhood.

PATIENT 6

DR. DIVELEY: This is a 59 year old man who entered with a five year history of epigastric fulness and distress following meals. There had been no true abdominal pain and no vomiting. His symptoms had been somewhat more marked for a year prior to his admission.

The series of gastrointestinal roentgenograms showed a large paraesophageal hiatus hernia. He was operated on through the left side of the chest, and a hernia sac was found which contained a considerable portion of the stomach. The sac was excised, the phrenic nerve was crushed and the defect was closed. The esophagus was shifted lateralward in such a manner that three sutures could be placed medial to the esophagus.

DR. DANIEL: This hernia is not unusual and is representative of the most frequent type of diaphragmatic hernia which we see. The patient's symptoms were distressing to him. He had, in addition to symptoms which were related to his stomach, a paroxysmal cough which was extremely troublesome and which had been present for two or three years. His cough has been relieved almost completely since operation, and symptoms which might be attributed to herniation of his stomach have also been completely relieved.

The operation was carried out transpleurally. We believe that it is better to perform these operations through the left thoracic wall because we can expose the diaphragm better transthoracically and we can free the esophagus with more ease. The esophagus should be freed from the diaphragm completely and shifted laterally so that firm tissue can be brought together in the mediastinum medial

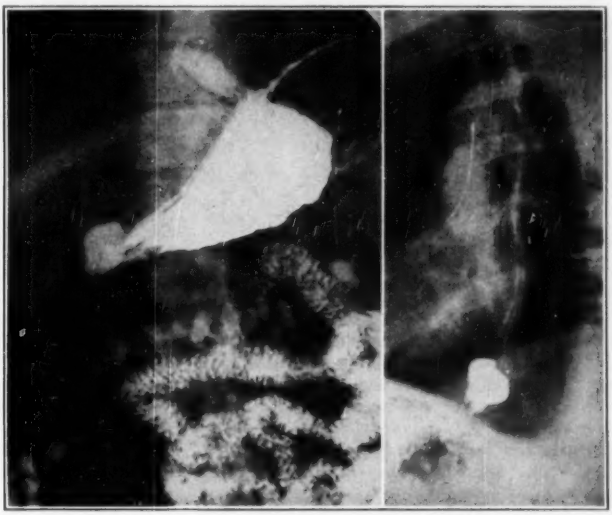

Fig. 6 (case 6).—Preoperative roentgenogram of a paraesophageal hiatus hernia in a 59 year old white man. This represents the most commonly observed type of diaphragmatic hernia.

to the esophageal wall as well as lateral to it. The hernia can be repaired satisfactorily through an abdominal incision, and many surgeons prefer this approach.

Dr. Billings, would you comment on the symptoms which are produced by hiatal hernia?

DR. BILLINGS: In a report of some 400 cases there is a comprehensive enumeration of the symptoms. Eighty-three per cent of the patients had epigastric fulness, some slight pain and discomfort and a feeling of bloating and indigestion usually following fairly shortly after a meal. Heartburn occurred in about half of these. Pain associated with meals and some regurgitation of food, especially in the supine position, were fairly frequent symptoms.

It is often difficult to make a specific and definite differential diagnosis between cardiospasm, diverticulum of the esophagus, gastric ulcer, duodenal ulcer,

cholecystitis or other disease of the upper intestinal tract on the basis of history alone. I certainly believe, therefore, that in many cases it is difficult to diagnose a paraesophageal hernia purely from the history. Moreover, diagnosis is made more difficult by the fact that in some instances the pain is referred to the anterior region of the thorax and on occasions even to the left hemithorax and down the left arm or even both arms. This occurs in about 8 per cent of patients.

In these circumstances, particularly in the middle-aged group, one is concerned with whether the coronary arteries are involved. In patients in whom a suggestive set of symptoms is present, pointing to coronary artery disease, elicitation of a careful history relating to the time of pain and the relief obtained from rest or nitrites and associating symptoms with an increased cardiovascular load or purely with digestive processes is necessary. By taking a careful history the presence or absence of angina pectoris should not be difficult to determine.

Relief or onset of symptoms in association with change of position shortly after a meal points to esophageal hernia.

The distribution or type of pain will usually not be helpful because the pain of angina pectoris notoriously can simulate almost anything.

DR. DANIEL: We have operated on a fairly small number of patients in this institution who have had hiatus hernia. I believe the number is much smaller than it should be, however. Symptoms continue once they have begun, as a rule, and although they rarely cause the death of the patient they may be extremely troublesome throughout the remainder of his life.

The operative procedure itself can be carried out with almost no risk. I would say, on the basis of the patients with hiatus hernia with whom I have come in contact, that approximately 25 per cent had symptoms troublesome enough to warrant operation.

Dr. Billings, do you think that is a fair estimate?

DR. BILLINGS: I would say that a higher percentage have symptoms justifying operation; and in addition to that, it might be well to bring up at this time the fact that in approximately 8 per cent of patients with paraesophageal hernia bleeding can take place frequently without other symptoms. The cause of this bleeding is poorly understood, although occasionally peptic ulcers have been demonstrated in the herniated portion of the stomach. An operation may be lifesaving when bleeding is profuse.

DR. ROSENFELD: Dr. Billings mentioned the diagnosis of achalasia or cardiospasm. A recent distressing experience with a patient brings up the speculation as to whether achalasia and hernia may coexist. This woman had symptoms for ten years; thorough barium studies showed no evidence of achalasia, but she had a large hiatus hernia. It was repaired without difficulty. We were sure we did not constrict the lower end of the esophagus. Postoperatively her condition went on to complete stenosis of the cardia. Six weeks later we had to do esophagogastrostomy.

If there is any question of the existence of achalasia before operation, it might be wise to open the stomach and be sure. I do not know of any other experiences like this.

DR. FRED GRAY: That brings out the question of the association of hiatal hernia with esophagitis and ulceration of the esophagus, which at times may go on, I presume, to stenosis, as in the case Dr. Rosenfeld mentioned.

DR. DANIEL: Yes, those conditions may coexist.

DR. FRANCIS: We used to see these hiatal hernias and could not get anyone interested in them. About ten or eleven years ago a tremendous interest

developed because of the similarity of the symptomatology with that of some cardiac lesions. The majority of the persons in whom we see these belong to the older age groups, and a large number of them, I think, are absolutely symptomless. They often have some symptoms around the abdomen. It is a vague story that no one can really put his finger on, and the gastrointestinal examination is made as a sort of exploratory program.

It is not infrequent to find these hernias to be of the sliding type—that is, in the erect position there is no herniation. With the patient lying down, at first there is no herniation, but during the course of the examination one may find a slow progression of the hiatal herniation. In some cases, depending on the degree of the laxity of the hiatus, barium may flow to and fro very readily. In others, one may have to use some procedure, such as the Valsalva, and also add pressure to the abdomen in order to show the passage of barium into a hiatal hernia.

Once in a while, one can actually see the hernia on the plain roentgenogram. It may not be recognized; a bubble of gas may be seen and herniation immediately suspected. This can then be confirmed with barium. I think the most important single differential point between the short esophagus and the paraesophageal type is distinguished with the first few swallows of barium because at that time one has the opportunity, particularly with the patient in the erect position, to see the barium come down through the esophagus, through the hiatus area, and identify the intra-abdominal esophagus. It is important to do that on inspiration and expiration in the erect and the supine positions in order to be reasonably sure that one can differentiate paraesophageal hernia from a short esophagus with a partial thoracic stomach.

PATIENT 7

DR. DIVELEY: This is a 43 year old man who two years prior to his admission was stabbed with a knife, wounds being inflicted in the abdomen and one wound over the left lower lateral region of the chest. He had had empyema on the left side which had drained for a period of several months.

About a year prior to his admission, cramping abdominal pain developed and he was operated on at another hospital for intestinal obstruction. From that time on, he continued to have cramping pain in the upper abdominal area and a feeling of fulness in the left side of his chest, and he vomited repeatedly.

He had lost a large amount of weight. The diagnosis was made by gastrointestinal examination. He was operated on through the left side of the chest, and a large herniated sac was found which contained a major portion of the stomach. This sac was dissected free without difficulty, and the defect in the diaphragm was closed. The phrenic nerve was crushed in this instance. His postoperative course was uneventful, and he has had no further gastrointestinal symptoms since operation.

DR. DANIEL: This is an example of the traumatic hernia in the posterior part of the diaphragm as the result of a stab wound. There were no serious symptoms for one year after the injury, probably because the patient had an infection.

The sac which was described at the time of operation, I am sure, was not a true hernia sac. That is, it was not truly composed of peritoneum or pleura but rather of adhesions which formed between the surface of the lung and the walls of the chest and the diaphragm and the wall of the stomach .

It was necessary to free the lung from the chest wall, the diaphragm and the stomach and to free the wall of the stomach from the diaphragm before it

was replaced into the abdominal cavity. Closure of the defect was then not difficult. These patients should be operated on as soon as the diagnosis is made unless the condition is so precarious that operation cannot be carried out at that time.

MR. SCHLANT: How frequently does strangulation occur in different types of hernia?

DR. DANIEL: Strangulation probably occurs more frequently in this type of hernia than in other types. The wound is frequently a simple incision through the diaphragm. It does not remain as an incised wound, the edges of which are close together, but the radial pull of the diaphragm tends to hold it open so that it becomes oval in shape and the wound edges retract. The abdominal viscera ascend into the pleural cavity with great ease on the left side.

This then concludes the program for today unless there are other comments. I think we might summarize the discussion by saying that diaphragmatic hernias may be classified into two large groups. There are those which result from developmental abnormalities, including the esophageal hiatus hernia, the hernia of the pleuroperitoneal foramen and the hernia of the subcostosternal space. Developmental abnormalities have been reported in other portions of the diaphragm, but they occur rarely. These types of hernia may or may not be present at the time of birth. Some of them may develop in later life as a result of congenital abnormalities in development. The second large group includes the traumatic hernia, which may be caused by various types of injuries.

The treatment is surgical repair. Patients with esophageal hiatus hernia should be subjected to operation only if symptoms are produced by the lesion. Operation is indicated in all other types of diaphragmatic hernia.

Surgical Forum

ESOPHAGEAL HIATUS HERNIA

The following questions regarding esophageal hiatus hernia have been circularized and the replies summarized herein. It should be emphasized that there is not much discussion of the large diaphragmatic hernias, which in general offer little difficulty in diagnosis and treatment.

1. Is there any exception to the fact that roentgenologic examination after a barium swallow is the only means of objective anatomic diagnosis?

The roentgenologic examination after a barium swallow may miss the diagnosis in the case of small hernias and those which are particularly easily reducible, especially if views are not taken in the head-down position. If the patient is examined in the usual position, no evidence of herniation may be detected. Mention is also made of the use of the esophagoscope, and one reply emphasized its importance, particularly in determining the presence of other lesions which may be associated with the hernia as well as the presence of etiologic factors in its production. On rare occasions anatomic diagnosis may await operation, as shown by one experience in which roentgen examination was repeatedly noncontributory, but in which operation, carried out because of persistent and characteristic symptoms, revealed a small hiatus hernia. Repair of this was followed by complete relief.

2. Once the anatomic diagnosis is made, what criteria justify operation?

In the case of large, irreducible lesions, even when unaccompanied with symptoms, operation is generally advised if the patient is a good risk. Accompanying ulcer or bleeding also justifies operation.

The most difficult cases are those in which the hernia is small and the symptoms equivocal. Many hernias are detected during routine roentgenologic examination of the gastrointestinal tract; in the absence of specific symptoms operation is not automatically justified. However, the term "specific symptoms" must be defined. Most observers agree that these consist of severe epigastric, especially retrosternal, pain, particularly when it is severer at night while the patient is in bed, and regurgitation of gastric contents. The presence of bleeding with or without pain is also noted in a few cases in which an ulcer is associated with the hernia.

In regard to the question of medical versus surgical therapy, the point is emphasized that there is really no medical therapy for the typical case except perhaps the treatment of obesity when this is present and the avoidance of the horizontal position after meals. Thus the indication for operation in the presence of a demonstrable hiatus hernia depends on the severity and specificity of symptoms. Since these are usually due to anatomic rather than functional changes, curative therapy should be directed toward correction of the anatomic lesion. When symptoms are not typical, the question naturally arises of whether they could be associated with the hernia; if disability is severe enough and other therapy fails, repair of the hernia may be justified and will be followed by relief in many cases.

3. (*a*) In regard to the operative procedure, what are the indications for crushing of the phrenic nerve?

Although the phrenic nerve may be crushed as a preliminary step during the repair of a diaphragmatic hernia through the thoracic approach, crushing of the phrenic nerve in the neck as the sole procedure is recommended only when a large

diaphragmatic hernia is present in an old person who could not tolerate a more radical operation. It acts merely as a palliative procedure since the effects are only temporary. It may relieve symptoms in patients who have an associated spasm of the lower part of the esophagus.

(*b*) Which approach is preferable, the abdominal or the thoracic?

Opinion is equally divided except that the thoracic approach is definitely indicated for hernias of large size because of the likelihood of adhesions between the viscera and the intrathoracic contents. The abdominal approach is more applicable to the small hernias and has the advantage of offering an opportunity for exploration of other intra-abdominal viscera as a possible cause of symptoms.

(*c*) Is transplantation of the esophagus to a new opening in the diaphragm indicated?

The majority of opinions expressed indicate no need for this procedure.

(*d*) Is fixation of the cardia of the stomach to the undersurface of the diaphragm ever useful as an auxiliary procedure?

Most surgeons do not use this procedure, but several do in one form or the other, particularly at the junction of the esophagus and the stomach. When there is marked elevation of the esophagus, the cardiac end of the stomach is best fixed to the undersurface of the diaphragm, and in many instances the lower portion of the esophagus is also sutured to the margin of repair in order to fix the esophagus at the level of the diaphragm.

4. What is the incidence of recurrence after operation; is secondary operation ever indicated?

Most experiences indicated that there are few, if any, recurrences, which supports the view that if the hernia repair is effective, relief of symptoms should be permanent. In only two replies 5 to 10 per cent of patients operated on have had persistent or recurrent symptoms after operation. One opinion emphasized that the danger of recurrence is higher when the hiatus hernia is posterior to the esophagus or extends to both the right and left side of the esophagus. Mention is made of only 1 patient in whom a secondary operation was necessary, and this patient had a recurrence of the hernia due to partial disruption of the suture line following repair.

There is a general feeling that more patients with hiatus hernia should be operated on than in the past and with greater assurance of relief of symptoms. For example, 1 patient is cited who had undergone at least four abdominal operations, including cholecystostomy, cholecystectomy, appendectomy and hysterectomy. There was no relief of the symptoms, which consisted of persistent epigastric pain, worse in the horizontal position. Although numerous roentgenologic examinations of the gastrointestinal tract were carried out, they were all noncontributory save one in which a definite, small, reducible hiatus hernia was detected. Operation verified the presence of the lesion, and a complete cure followed its repair. In another case such a small hernia was found in a roentgenogram made after a barium swallow that it seemed unlikely that it could be responsible for the severe attacks of pain in the chest which the patient described. Although the patient was a chronic complainer and had undergone several abdominal operations, repair of the hernia was followed by complete subsidence of symptoms.

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